MONITORING SALT MARSH VEGETATION (Revision #1)

A Protocol for the National Park Service's Long-Term Monitoring Program, Northeast Coastal and Barrier Network

Mary-Jane James-Pirri
Graduate School of Oceanography
University of Rhode Island
Narragansett, RI 02882
mjjp@gso.uri.edu

Charles T. Roman
National Park Service
Graduate School of Oceanography
University of Rhode Island
Narragansett, RI 02882

December 2004

An Adaptation of:

Roman, C.T., M.J. James-Pirri, & J. F. Heltshe. 2001. Monitoring Salt Marsh Vegetation: A Protocol for the Long-term Coastal Ecosystem Monitoring Program at Cape Cod National Seashore. Coordinated by the USGS Patuxent Wildlife Research Center, Coastal Research Field Station at the University of Rhode Island, Narragansett, RI 02882.

TABLE OF CONTENTS

Table of Figures

Part 1

Table of Tables

Part 1

Part 2

Appendix

The Protocol Narrative

This protocol is an adaptation of the protocol developed by Roman *et al*. (2001) for use in the Long-term Coastal Monitoring Program at Cape Cod National Seashore. The original protocol can be found at the National Park Service Inventory and Monitoring website: http://www.nature.nps.gov/im/monitor/protocoldb.cfm. Extensive portions of text have been borrowed from Roman *et al*. (2001) and are presented in this document.

Protocol Background

National Park Service (NPS) managers need accurate information about the resources in their care. They need to know how and why natural systems change over time, and what amount of change is normal, in order to make sound management decisions. Therefore, the National Park Service has begun natural resource monitoring throughout the National Park System to gather this information as part of the Natural Resource Challenge program. A key component of this effort, known as Park Vital Signs Monitoring, is the organization of approximately 270 park units into 32 monitoring networks to conduct long-term monitoring for key indicators of change, or "vital signs." Vital signs are measurable, early warning signals that indicate changes that could impair the long-term health of natural systems. Early detection of potential problems allows park managers to take steps to restore ecological health of park resources before serious damage can happen. This protocol describes how to monitor salt marsh vegetation communities as part of the NPS Park Vital Signs Monitoring Program.

Since estuaries are the link between land and sea many of the practices on land (agriculture, industry, and urban and residential development) can directly impact the quality of estuarine resources and ecosystems. Threats to estuarine ecosystems include eutrophication, watershed development, wetland loss, changes in hydrology, sedimentation, and human-induced problems. Salt marsh ecosystems provide essential nursery habitat for recreational and commercial fishery species (Nixon and Oviatt 1973; Able *et al.* 1988; Heck *et al.* 1989, 1995; Ayvazian *et al.* 1992) and are an especially important habitat for forage species (Roman *et al.* 2000). The role of salt marshes in supporting migratory shorebird and waterbird populations is well-documented (*e.g.*, Burger *et al.* 1982; Brush *et al.* 1986). Salt marshes also serve as nutrient filters, intercepting and absorbing land-derived runoff, thereby reducing nutrient input to estuarine and coastal waters (*e.g.*, Howes *et al.* 1996). Physically, salt marshes can buffer upland areas from erosion and storm waves (Dean 1979). Salt marshes respond to global changes such as sea level rise. Sea level along the Atlantic coast is estimated to increase by 0.5m by 2100 (Intergovernmental Panel on Climate Change, 1995) and changes in salt marsh vegetation or the conversion of marsh to mudflats or open water may result if marshes cannot keep pace with sea level rise (Titus 1991). Some salt marshes in the northeast have documented vegetation changes indicating that they are getting wetter and tending toward submergence or drowning (Warren and Niering 1993; Roman *et al.* 1997; Donnelly and Bertness 2001; Kracauer-Hartig et al. 2002). Other factors related to climate change can also affect salt marsh vegetation. For example, with increased air

temperatures, evaporation will accelerate leading to an increase in marsh salinities, perhaps resulting in the expansion of extreme salt tolerant halophytes and unvegetated marsh pannes. At present, salt marshes in more southern latitudes (*e.g.*, southeast Atlantic), with warmer climates, generally have a greater occurrence of halophytes adapted to extremely high soil salinity conditions (Bertness 1999). Fig. 1 identifies some of the linkages between human-induced and natural environmental stressors (*e.g.*, altered hydrology, nutrient enrichment, storms, and sea level rise), associated changes in estuarine habitat structure, and responses of the salt marsh vegetation community.

An estimated fifty percent of the nation's coastal wetlands have been completely lost, mostly by filling and dredging activities (Dahl 1990; Tiner 1984). Salt marshes that remain often have a long history of alteration from extensive networks of ditching for mosquito control or salt hay farming purposes, from restriction of tidal exchange by roads, causeways, bridges, and dikes, and from widespread watershed development activities (Daiber 1986; Roman *et al.* 2000). Plant species composition of salt marshes dramatically changes in response to ditching activities (*e.g.*, Bourn and Cottam 1950; Niering and Warren 1980) and restriction of tidal flow (*e.g.*, Roman *et al.* 1984, 1995). With ditching, the marsh may become drier and less salt- or flood-tolerant species may dominate (*e.g.*, *Iva frutescens* and other high marsh species), while restriction of tidal flow often results in conversion of *Spartina*-dominated to *Phragmites australis*-dominated marshes. Conversely, re-establishment or restoration of hydrologic conditions that were altered by ditching or tidal restriction often initiates a change or recovery back to typical marsh vegetation (Burdick *et al.* 1997).

This protocol was developed for monitoring salt marsh vegetation as part of the Long-term Coastal Ecosystem Monitoring Program at Cape Cod National Seashore, and is here adapted to the broader set of national parks in the Northeast Coastal and Barrier Network and the Northeast Temperate Network. Percent cover of salt marsh vegetation is estimated using a $1m^2$ plot using one of two methods, the point intercept or the visual cover estimation method. We recommend sampling salt marsh vegetation with at least 20 replicate $1m^2$ plots per marsh. Other aspects of vegetation sampling are discussed, including seasonal sampling considerations, transect and plot location, and associated environmental data sampling. Developing and initiating long-term salt marsh monitoring programs will help track natural and human-induced changes in salt marshes and advance our understanding of the interactions between marsh ecosystems and the estuarine environment.

Protocol Objectives

Specific objectives and monitoring questions addressed by the Salt Marsh Vegetation Protocol have been developed in association with those for the salt marsh nekton and salt marsh elevation: :

Objective 1: To understand long term changes in salt marsh vegetation and nekton communities.

- **Question 1:** *Are salt marsh vegetation patterns (species composition and abundance changing over time (e.g., decades)?*

  - **Vital Sign 1:** Salt Marsh Vegetation Community Structure
- **Question 2:** *Is nekton community structure (species composition, abundance, and size structure) changing over time (e.g., decades)?*
  - **Vital Sign 1:** Salt Marsh Nekton Community Structure

Objective 2: To understand responses of salt marsh vegetation and nekton communities to environmental change.

- **Question 1:** *How do salt marsh communities change in response to perturbations (e.g. invasive species, oil spills, storms) in the environment?*
  - **Vital Sign 1:** Salt Marsh Vegetation Community Structure
  - **Vital Sign 2:** Salt Marsh Nekton Community Structure

Objective 3: To understand how salt marsh elevations respond to local sea-level rise.

- **Question 1:** *Are salt marsh surface elevation trajectories changing over time (e.g., decades), and if so, what factors are contributing to observed elevation changes (e.g., surface versus subsurface processes, changes in organic matter accumulation)?*
  - **Vital Sign 1:** Salt Marsh Sediment Elevation
- **Question 2:** *Are salt marsh surface elevation trajectories keeping pace with the local rate of sea-level rise?*
  - **Vital Sign 1:** Salt Marsh Sediment Elevation

Protocol History

The original protocol (Roman *et al*. 2001) was developed at Cape Cod National Seashore, an NPS prototype monitoring park. Development of this protocol was based on quantitative data presented in Roman *et al*. (2001). From these data guidelines for the temporal and spatial frequency of sampling, replicate sample size, and statistical analyses were developed and are presented in the protocol.

The salt marsh vegetation protocol has been implemented at several US Fish and Wildlife Refuges (USFWS) from 2000 to 2004 along the Atlantic Coast (USFWS Region 5) as part of an ongoing study to examine the effects of open marsh water management on salt marsh ecosystems (James-Pirri *et al*. 2004) (Fig. 2). As part of the Inventory and Monitoring Program this protocol has been tested at 7 National Parks (as of 2004) within the NCBN and the NETN. In the summer of 2003, the protocol was tested at Colonial National Historical Site (COLO), Fire Island National Seashore (FIIS), and Gateway National Recreational Area (GATE). In 2004, the protocol was tested at Cape Cod National Seashore (CACO), Sagamore Hill National Historic Site (SAHI), Boston Harbor Islands National Park Area (BOHA), and Saugus Iron Works National Historic Site (SAIR). Additional pilot studies are scheduled to begin in 2005 at Assateague Island National Seashore (ASIS), George Washington's Birthplace National Monument (GEWA), and possibly Acadia National Park (ACAD).

Data collected from the salt marsh vegetation protocol will help address issues and concerns not only at the estuary, park, and Network level but also at the Regional level.

The General Conceptual Model (Fig. 3) for the Northeast Coastal and Barrier Network identifies major external activities or processes that influence the natural system (Agents of Change), the associated problems or products of human activities or natural events that alter the quality or integrity of the ecosystem (Stressors), and the measurable changes in ecosystem structure, function, or processes (Ecosystem Indicators). Since salt marsh vegetation responds to environmental change (*e.g*., sea level rise, changes in hydrology, invasive species colonization), a program that monitors salt marsh vegetation will be able to detect changes or shifts in species composition and abundance providing an early warning system to larger ecosystem threats or alterations, and will advance our understanding of the interactions between salt marsh communities and the dynamic estuarine environment.

Protocol Summary

This protocol (Narrative and Standard Operating Procedures [SOPs]) describes the methods used to sample salt marsh vegetation and associated cover types (*e.g*., water, bare ground, wrack or litter), as well as ancillary groundwater and soil salinity information, and is a revision of the Salt Marsh Vegetation Monitoring Protocol developed by Roman *et al.* (2001). The following recommendations for sampling procedures follow those put forth by Roman *et al*. (2001). A minimum of 20, $1m^2$ vegetation plots should be sampled for salt marsh vegetation at each selected monitoring location. **The preferred method for estimating vegetation and other cover classes is the point intercept method, however in situations where the vegetation canopy is very tall, the visual estimation method can be used.** At each plot, species composition is recorded and the percent cover is estimated for each cover class. Salt marsh vegetation is sampled once per year, near the end of growing season.

We suggest monitoring groundwater table level and soil salinity in conjunction with monitoring salt marsh vegetation, as these data can aid understanding some of the fundamental causes of vegetation change. Groundwater table level is measured in groundwater wells installed adjacent to vegetation plots. Soil salinity is measured using a soil probe adjacent to vegetation plots. Groundwater table level and soil salinity are monitored every 7 to 10 days throughout the growing season. Additionally, the height of key species, such as *Phragmites australis*, will also be measured as a component of vegetation monitoring. For example, *Phragmites* height will indicate the vigor of the species and its response to changes in hydrology or salinity regime.

Sampling Design

The sampling design of the Salt Marsh Vegetation Protocol has been developed after extensive research and sampling in the field. The rationale for the sample design is discussed in detail in Roman *et al*. (2001) and is briefly presented in this section. The following questions have helped shape the development of this protocol, and the sampling design and methods for the salt marsh vegetation protocol are best described in terms of these questions.

<u>What is the population of interest?</u>

The populations of interest are the salt marsh vegetation communities as a whole as well as individual species and associated cover classes (*e.g*., bare ground, water, wrack or litter) in each of the selected salt marshes within the coastal parks of the NCBN and NETN.

What is measured?

The measurements of importance in the Salt Marsh Vegetation Protocol are vegetation species composition and the percent cover for plant species and associated cover classes (*e.g*., bare ground, water, wrack or litter).

Additional data on groundwater table level and soil salinity will be monitored concurrently with the salt marsh vegetation. It is important to quantify vegetation changes, but it is also valuable to understand why the species composition or abundance of salt marsh plants is changing. Several interacting factors influence salt marsh vegetation patterns, such as frequency and duration of tidal flooding, salinity, substrate, soil oxygen, nutrient availability, disturbance by wrack, and competition among plant species (*e.g.*, Niering and Warren 1980, Nixon 1982, Bertness 1999, Roman 2001). Therefore, in association with the $1m^2$ vegetation plots, it is recommended that the following variables be monitored in an effort to enhance our understanding of causal mechanisms for observed vegetation changes.

Water table level – Indicator of soil drainage or soil waterlogging.
Soil salinity – Indicator of salt stress.
Height of key species such as *Phragmites australis*

What is the appropriate sampling unit?

The sampling unit is a $1m^2$ plot. A $1m^2$ plot provides a quantitative estimate of the percent cover of vegetation species and associated cover classes (*e.g*., bare ground, water, wrack or litter) present in salt marshes.

Plots are clearly the most common type of sampling unit for grassland communities, like salt marshes (Kent and Coker 1992; Elzinga *et al.* 1998). This is due to the relatively small size and stature of vegetation, the relative ease of locating and sampling in plots, and the utility of plot sampling for summarizing and analyzing vegetation data. Species area curves, from data collected Cape Cod National Seashore's Hatches Harbor salt marsh, suggest that a square $1m^2$ quadrat is appropriate (Roman *et al*. 2001). As noted for the typical salt marsh habitat, few species occur (5 species maximum within a plot, and often just 2 or 3) and a plot size of $1m^2$ is more than adequate. In fact, a $0.5m^2$ plot would be appropriate (*i.e.*, increasing the plot size beyond $0.5m^2$ does not result in an increased number of species being recorded). However, as the vegetation community becomes more complex (up to 15 species per plot) a $1m^2$ plot size may be required. Roman *et al*. (2001) plotted species area curves for 20 randomly selected marsh plots and determined that for 80% of the sampled plots the species area curves leveled-off or reached a plateau at $1m^2$. To further confirm that a $1m^2$ plot is adequate, Roman *et al.* (2001) performed a one-way Analysis of Similarity (ANOSIM; Carr 1997) to compare the vegetation community (species composition and abundance) using data from $0.1m^2$,

$0.25m^2$, $0.5m^2$, $0.75m^2$ and $1m^2$ plots. Alpha levels for the 4 pairwise comparisons ($0.1m^2$ vs. $1.0m^2$, $0.25m^2$ vs. $1.0m^2$, $0.5m^2$ vs. $1.0m^2$, $0.75m^2$ vs. $1.0m^2$) were Bonferroni adjusted (Zar 1999; Rice 1989) and a significant difference was only noted for the $0.1m^2$ vs. $1.0m^2$ comparison. In other words, when the vegetation community as defined by the twenty $0.25m^2$, $0.5m^2$ or $0.75m^2$ plots was compared to the same 20 $1.0m^2$ plots, there was no detectable difference in the vegetation community. Therefore, we are confident that the $1.0m^2$ plot is adequate (Roman *et al.* 2001).

How should the sampling units (plots) be positioned?

There are often distinct zones of salt marsh vegetation encountered from tidal creeks toward the upland border of salt marshes (Niering and Warren 1980). At creek banks, the marsh is flooded twice daily by tidal action, commonly called the low marsh. Here, *Spartina alterniflora* usually dominates. With a progression landward, elevation of the marsh surface is increased and the marsh is flooded less frequently. This zone is referred to as the high marsh. Typical plants of the high marsh include *S. patens*, *Distichlis spicata*, short form *S. alterniflora*, and *Juncus gerardii*. At the upland border, there is often a zone of species that is less tolerant of flooding and high soil salinities, including *Iva frutescens*, *Panicum virgatum*, and *Phragmites australis*. Because of this distinct gradient of elevation and frequency of tidal flooding, and corresponding responses of vegetation to this gradient, sampling along transects from the creek bank to the upland border is necessary. Sampling along transects, established across the elevation gradient, will insure that all vegetation cover types along the gradient are sampled (Roman *et al.* 2001).

In order to adequately sample the study area, it is necessary to systematically divide the study area into sections. In this case the total number of transects should be evenly divided among the sections and then randomly located within each section (Fig. 4). The systematic division of the area into sections with the random placement of transects within each section and randomization of the first plot within each transect provides better interspersion of samples within the sample area (Elzinga *et al.* 1998). Excellent discussions are provided in the literature to justify the use of transects when sampling along environmental gradients and the use of stratified techniques (*e.g.*, the elevation gradient; Kent and Coker 1992; Sutherland 1996; Elzinga *et al.* 1998; Neckles and Dionne 2000; Neckles *et al.* 2002). After dividing the marsh into sections, creek bank to upland transects are located randomly within each section. It is important to locate transects in a random manner. As stressed by Elzinga *et al.* (1998), random sampling must be incorporated into the study design to reduce bias and support the application of inferential parametric statistics.

There is no set number of sections per marsh, however, since one or more transects are randomly located within each section it is suggested that sections should cover an area that adequately represents the marsh being studied. For example, we typically divide a marsh into three or more sections, yielding 3 or more transects per marsh. The total number of plots per marsh should then be dispersed as evenly as possible among transects (Roman *et al.* 2001). To maintain independence of the $1m^2$ plots, they should be spaced at least 10m apart, therefore all transects should be spaced at least 10m apart. The

location of the first plot is selected randomly within the pre-determine plot distance (the selected distance between adjacent plots). Plots are then systematically located along each transect from the creek bank to upland. This distance is the same distance between adjacent plots along the transect and is dependent on the length and total number of transects within a marsh. Once the first plot is located, subsequent plots are located at consistent intervals along each transect (*e.g*., every 10m, 20m, 30m or 40m, *etc*.). Plots should be spaced far enough apart so that adjacent plots are not correlated and are considered independent. In the salt marsh environment, a distance of 10m or greater, should be sufficient. During sampling the actual location of each $1m^2$ vegetation plot is offset from the plot stake to prevent trampling of vegetation within the plot. The offset of the vegetation plot is 1m to the right in the direction of the transect when facing higher plot numbers.

Figure 1-4 provides an example of how vegetation transects should be oriented perpendicular to the tidal creek. To establish the creek bank to upland transects, the marsh was divided into three equal-sized sections. One or more transects are randomly located within each section. Dividing the marsh into sections insures interspersion of plots throughout, but still maintains a random, unbiased method.

By following this design, with random location of transects and a random starting point for the plots along each transect, each plot can reasonably be assumed to be independent and thus serves as a single sample unit. Thus, it is assumed that each plot was selected as a simple random sample and the data set can be analyzed as such (Elzinga *et al.* 1998).

To summarize, each sample marsh is divided into sections to ensure adequate spread of plots. One or more transects are randomly located within each marsh section. All transects are oriented perpendicular to the main elevation gradient of the marsh (*e.g*., from tidal creek to upland). If no elevation gradient is apparent or if there is no defined tidal creek, transects traverse the marsh from upland to upland. If possible, all transects should be parallel to each other. The $1m^2$ vegetation plots are positioned along transects and the first plot is randomly located. All subsequent plots are located systematically along the length of the transect at pre-determined intervals (*i.e*., 10m, 20m, 30m, *etc*.). The interval between adjacent plots is dependent on the length and the total number of transects per marsh. During sampling, the actual sampled vegetation plot is offset from the plot stake 1m to the right when facing the direction of higher plot numbers.

How many sample units should be taken?

At least 20 replicate $1m^2$ plots should be monitored per marsh. A power analysis was conducted to determine the appropriate sample size for sampling salt marsh vegetation using $1m^2$ plots (Roman *et al.* 2001). The objective of this power analysis was to determine the minimum number of sample replicates that are necessary to detect changes between vegetation communities of salt marshes. Power is a function of the differences between two populations, the sample size, the alpha level of the test (the probability of detecting a difference between two datasets when no difference exists, *i.e*., Type I Error), and the variability of the measured response.

To estimate power we used Braun-Blanquet percent cover data obtained from $1m^2$ vegetation quadrat sampling of eleven salt marshes from Rhode Island to Maine. These marshes varied from relatively unimpacted to severely impacted (due to tidal restriction), and included marshes that had recently undergone tidal restoration. To look at power as a function of the similarity (as measured by Euclidean distance) between two populations, seventeen pairs of vegetation data sets were selected that exhibited a range from similar (*e.g.*, a RI marsh sampled in 1998 vs. the same marsh sampled in 1999) to quite different vegetation composition (*e.g.*, a tidal restricted marsh in RI vs. an unimpacted marsh in Maine. The power of the permutation testing procedure outlined in Clarke and Green (1988) and Smith *et al.* (1990) was used. This procedure allows statistical testing of equality between two vegetation communities and uses a measure of similarity between two populations as a test statistic. In this case the Euclidean distance similarity index (Krebs 1999) was used. Vegetation communities similar in composition will have small distances and less similar communities larger distances between them. For each pair of vegetation communities we randomly selected sample sizes of 5, 10, 15, and 20 from each vegetation community and applied the permutation testing procedure to determine the rejection or acceptance of the null hypothesis, at an alpha level of p=0.05, of no difference between the data sets for each trial. Two hundred (200) trials for each sample size for each pair of marshes were performed to determine the power to detect a difference between two marshes. Empirical power was estimated as the number of rejections by the permutation procedure out of the 200 trials.

The results of the power analyses are shown in Fig. 5. In this figure the horizontal axis indicates the similarity or "sameness" of two different salt marsh communities (using Euclidean distance as a similarity index) with those communities that are similar at the left portion of axis and those that are different on the right portion of the axis. From this analysis we can estimate the statistical power of detecting a difference between two vegetation data sets. With n=5 there is a low power to detect most differences, even for many cases where the differences between the two data sets are great. Increasing the sample size to n=10, 15, or 20 samples per marsh substantially increases the power to detect a difference between marshes even if the marshes are relatively similar. A power above 0.9 means there is a >90% chance of detecting a difference between vegetation data sets when a difference actually exists. With a low power there is an increased probability of not detecting a difference when the data sets are actually different (*i.e.*, Type II error). From the power curve (Fig. 5) it becomes clear that with n=15 or 20 there will be a high probability of detecting a change between data sets that are quite similar. If an investigator were interested in detecting subtle changes between vegetation data sets (*e.g.*, comparing vegetation from Marsh A over two consecutive years), then it would be appropriate to have a large number of replicates. If dramatic changes were of interest and expected, such as comparing a tide-restricted marsh to a natural marsh, then a smaller number of replicates would be justified.

The required replicate size of 20 plots per marsh site is the same regardless of the size of the marsh that is being sampled. This is because the proportion of the marsh that is actually being sampled (*i.e.*, 20 replicate $1m^2$ plots $=20m^2$) is very small compared to the entire area of the marsh that could be potentially sampled (*i.e.*, 1ha marsh = $10{,}000m^2$),

therefore for a 1ha marsh 20 replicate $1m^2$ plots comprises only 0.2% of the total area available for sampling. For larger marshes, the proportion of area sampled is even less. The general rule is that if the area sampled is less than 5% of the total sample area it is not necessary to alter the replicate size by applying the finite population correction factor (Elzinga *et al.* 1998; Krebs 1999).

To summarize, for salt marsh vegetation monitoring, it is recommended that a minimum of 20 plots be established within each marsh study area. It is noted that n=15 would probably be an adequate number of replicates (based on the power curves) to detect the kinds of long-term salt marsh vegetation changes that would be of interest in long term monitoring programs; however, given the relative ease of collecting vegetation plot data, we are recommending a sample size of n=20 to effectively detect even subtle vegetation changes.

Groundwater table level and soil salinity should be taken at each vegetation plot for a total of at least 20 replicate station locations per marsh. Height of key species, such as *Phragmites australis*, is measured in plots where that species occurs.

When will the samples be taken?

The optimal sampling time for salt marsh vegetation is during the period of peak biomass from July through early September. Most plants are either flowering or fruiting during this period, thus making identification easier. Sampling during additional seasons is not recommended.

Sampling frequency over the long-term depends on the projected rate of salt marsh vegetation change. Vegetation changes that are responding to longer-term factors, like sea level, as opposed to dramatic hydrologic alterations, may occur over decades or centennial time scales, but nonetheless, significant changes do occur. Warren and Niering (1993), studying a Connecticut salt marsh, found that over a 40-yr period the vegetation of some portions of the marsh remained remarkably stable, while other areas displayed significant changes. The areas where vegetation did change had lower rates of marsh surface accretion, and thus, rising sea level may be a factor contributing to the changes (Warren and Niering 1993). At Cape Cod's Nauset Marsh, Roman *et al.* (1997) studied rhizomes in salt marsh peat cores and found relatively stable vegetation patterns for a century, or so; however, there was one portion of the marsh where vegetation changes were noted over the past four decades – also suggested as a response to an accelerated rate of sea level rise. Miller and Egler (1950) eloquently describe salt mash vegetation change as follows; "The present mosaic may be thought of as a momentary expression, different in the past and destined to be different in the future yet as typical as would be a photograph of moving clouds."

To summarize, when addressing questions of vegetation change in response to long-term and large-scale issues, it is recommended that sampling initially be established at 3-5yr intervals. If significant changes are occurring during this interval, then more frequent sampling should be considered. Alternatively, a longer interval, perhaps 7-10yrs could be adopted if initial monitoring reveals a stable community. Monitoring will initially be

conducted at 3 year intervals for all sites covered in this protocol. It is also recommended that an additional round of monitoring be conducted following any major events, such as hurricanes, formation of new inlets, or oil spills.

Groundwater table level and soil salinity should be taken every 7-10 days through out the growing season within 2hrs of low tide. Height of key species can be measured during vegetation monitoring.

Should sampling units be permanent or temporary?
Vegetation plots are permanent. In order to make plots permanent, permanent markers (often two per plot, one placed at each diagonal) are required to relocate the exact same $1m^2$ area that was previously sampled. The groundwater well can be used as one of the permanent markers, however, samplers must be careful not to trample the vegetation plot during water table level sampling. This requires that plot stakes (or groundwater wells, if monitored) are left on the marsh. GPS coordinates will not re-locate the exact location of a permanent plot, but will locate the vicinity (within 2 to 5m) of the previously sampled $1m^2$ plot.

Permanent plots are located randomly during the first year of sampling, and then are re-located every additional sampling year. Water table level (measured in groundwater wells) and soil salinity are measured at each vegetation plot, and since the groundwater wells are permanently installed (removing and re-installing wells every sample year is not practical and would be disruptive to the marsh), the vegetation plots associated with the wells must also be permanent. It will be necessary to make an additional visit to the marsh prior to any sampling to re-locate or re-establish permanent plots if the marker stakes or wells have been lost (due to storms, ice scour) over the winter months.

What sites are sampled?
Study sites will be selected using a stratified random sampling design, if more than two sites are available within the park. For example, if the there is an extensive stretch of salt marsh (such as at FIIS or ASIS) the entire salt marsh system will be stratified and sampling locations will be randomly selected within each stratum. An example of stratification that might be used would be distance from an inlet. Other factors such as access logistics, co-location with existing monitoring programs, and size of the salt marsh must also be considered when randomly selecting sites to monitor.

For many NCBC and NETN parks there are fewer than two salt marshes within the park (*e.g.* BOHA, GATE, GEWA, SAIR, SAHI). In these instances, there are only one or two areas to sample, and those areas will be monitored.

As of the summer of 2005, we have sampled salt marsh vegetation using this protocol at several National Park Service sites. Sites within parks were selected as follows.

Assateague Island National Seashore (ASIS): Study locations were randomly selected within strata of grazing intensity by ungulates (*i.e.*, ponies). Grazing (an important resource issue at ASIS) intensity strata were low grazing, moderate grazing, and high

grazing. Areas of grazing intensity were identified by ASIS Resource Management staff, and overlaid with grid (500m by 500m grid cells) in GIS. All grid cells were numbered and three grid cells ($500m^2$) were randomly chosen from the population of available grids within each strata. Three random grid cells were chosen as it was necessary to have back-up grid cells if logistical issues (i.e. access to sites) or co-location of other sampling efforts [*i.e*., sediment elevation tables, (SETs)] prevented the use of a particular randomly selected grid. Study locations at ASIS are the North End Marsh (high intensity grazing), an unnamed marsh (moderate intensity grazing), and Valentines Marsh (high intensity grazing). Maps of study locations will be included after stations have been sampled.

Boston Harbor Islands National Park Area (BOHA): Thompson Island and Calf Island marshes were sampled in 2004 (Figs. 6 & 7). These were the only 2 salt marshes within BOHA that were of sufficient size to place the required 20 vegetation plots.

Colonial National Historical Site (COLO): Back River Marsh (on Jamestown Island) and Kings Creek Marsh (on the York River) were sampled in 2003 (Figs. 8 & 9). Back River Marsh was chosen as a sampling location because resource management required information on the marsh for the Jamestown Project (C. Rafkind, pers. comm). Kings Creek was chosen as a representative estuarine salt marsh for COLO. This site was specifically chosen due to access issues at other sites.

Fire Island National Seashore (FIIS): Hospital Point and Watch Hill Marshes were sampled in 2003 (Figs. 10 & 11). Sediment Elevation Tables (SETs) were already established at both sites and it was decided to co-locate vegetation sampling with the SETs. The marsh area where the SETs were located was chosen using a stratified random design with distance from the inlet as the stratification (C. Roman, NPS, pers. comm.). Access to the site was also a consideration for the SET locations.

Gateway National Recreation Area (GATE): Horseshoe Cove marsh within Sandy Hook Unit was sampled in 2003 (Figs. 12 & 13). Horseshoe Cove is the only marsh on Sandy Hook of sufficient size to sample the required number of vegetation plots (n=20). Additionally, Sediment Elevation Tables (SETs) were already established at Horseshoe Cove and it was decided to co-locate vegetation sampling with the SETs. Vegetation at Big Egg marsh, within the Jamaica Bay Unit of GATE has been sampled by staff at GATE as part of a restoration project (G. Frame, NPS, pers. comm.). Vegetation sampling protocols at Big Egg are different than those described in this document.

George Washington Birthplace National Monument (GEWA): There are only two tidal salt marshes within GEWA. These marshes are Pope's Creek (including the islands within Pope's Creek) and Dancing Marsh. Due to the small size of both marshes, the entire marsh area is the study site.

Saugus Iron Works National Historic Site (SAIR): The salt marsh along the Saugus River was sampled in 2004 (Fig. 14). This is the only salt marsh within the park.

Sagamore Hill National Historic Site (SAHI): The salt marsh adjacent to Cold Spring Harbor was sampled in 2004 (Figs.15 & 16). This is the only salt marsh within the park.

Sampling Methods

Point Intercept and Visual Cover Estimation Methods

This protocol is designed to monitor changes in species composition and the abundance of each species within each sample marsh. Therefore the identity of each species and an estimate of the abundance of each species must be determined for each plot. Cover is a common measure of species abundance in vegetation studies. Two methods of estimating percent cover, the point intercept estimate and the visual cover estimate, are widely used in grassland habitats and the merits and shortcomings of each have been reviewed by many (*e.g.*, Poissonet *et al.* 1973; Floyd and Anderson 1987; Kent and Coker 1992; Elzinga *et al.* 1998). In brief, for the point-intercept method the observer records each species that is intercepted by each point in a grid of 50 or 100 points within each plot. This method has a sound theoretical basis; the proportion of points intercepted by each species equals the cover of that species. For the visual cover estimate, the observer stands over the plot and visually estimates the cover of each species present within the plot. Cover is typically estimated within standard cover classes, such as the Braun-Blanquet cover scale (0: absent; 1:<1%; 2:1-5%, 3:6-10% 4: 11-25%; 5:26-50%, 6:51-75%, 7:76-100%). In statistical analyses the Braun-Blanquet data are analyzed as categorical data (e.g. 0 to 7 scale for categories).

The point intercept method is the preferred sampling method as this technique relies upon the objective process of data collection and is repeatable with little variation among different field staff, whereas the visual cover estimate requires more training, is a more subjective method, and thus is less likely to have the repeatable precision of the point intercept method. Therefore, to reduce observer bias (*i.e.*, subjective decision-making by the observer) in a monitoring program that will be ongoing for several decades and will include many different teams of field personnel, we recommend the point-intercept method. It should be noted that we have used the visual cover method in salt marsh vegetation studies and find it to be a reliable method (Roman *et al.* 2002). In that study, Roman *et al.* (2002) compared vegetation among several sampling years, but the same team of field observers was used reducing any bias associated with the subjective assessment of vegetation cover. Both methods are presented in this protocol as **there are instances (*e.g.*, tall vegetation canopies) where the point intercept method is difficult to conduct.**

The point intercept method is considered by many to be the least biased and most objective method (*e.g.*, Floyd and Anderson 1987, Elzinga *et al.* 1998). The observer merely needs to record the species that each point hits or intercepts. One possible shortcoming of the point intercept method is that it may under-represent narrow-leaved and vertically-oriented species such as many graminoids as compared to broadleaf species, due to the nature of the vertical rod used, however in salt marshes the majority of cover is composed of graminoid species, and therefore any such effect would be reduced compared to other vegetation communities.With the visual cover method, the observer

must decide the cover class that each species should be assigned. Observer bias can be quite high with the visual estimate method (*e.g.*, Greig-Smith 1983, Kennedy and Addison 1987); however, others strongly argue that the visual method yields similar results when compared to intercept methods (*e.g.*, Poissonet *et al.* 1973; Smartt *et al.* 1974, 1976; Kent and Coker 1992). It should be noted that we have used the visual cover method in salt marsh vegetation studies and find it to be a reliable method (Roman *et al.* 2002). In that study we compared vegetation among several sampling years, but the same team of field observers was used reducing any bias associated with the subjective assessment of vegetation cover. Based on the literature, use of either method could clearly be justified. However, to reduce observer bias (*i.e.*, decrease subjective decision-making by the observer) in a monitoring program that will be ongoing for several decades and will include many different teams of field personnel, we recommend the point-intercept method.

The point-intercept method to be used in this protocol is described as follows. As shown in Fig. 17, the $1m^2$ plot is divided into a grid of 50 evenly spaced points. A thin rod (3mm diameter), or bayonet after Poissonet *et al.* (1972), is held vertical at each point and dropped straight through the canopy to the sampling point on the ground. At each point of the grid, all species that touch/hit the bayonet are recorded. To calculate cover, for example, species A had 10 hits, yielding a 20% cover (10 hits/50 total points). Prior to sampling the quadrat it is useful to record all species within the plot on the data sheet. Roman *et al*. (2001) determined that 50 points per $1m^2$ were appropriate for sampling by the point intercept method. They compared the species composition and abundance for 45 randomly selected plots within Hatches Harbor (Cape Cod National Seashore) as sampled by 50 and 100 points. Analysis of Similarity (PRIMER software package, Carr 1997) showed no difference in the vegetation community when comparing the same plots with a 100 versus 50 point grid. Some investigators have noted that the point-intercept method may tend to miss rare species that occur within plots (see Elzinga *et al.* 1998). We have no data to quantify the species missed by sampling with a 100-point grid per $1m^2$, however, we can state with some certainty that missing rare species was not a problem. Roman *et al*. (2001) defined a rare species as one that occurred in just one of the 45 plots sampled and with a cover of $\leq 3\%$. Assuming that the 100-point data set sampled all rare species, Roman *et al.* (2001) reported missing only 4 species from a total of 68 species when analyzing the data based on a 50-point grid. These missed species were extremely rare. Using the 50-point grid, they detected 85% (23 of 27) of the rare species (as defined above) that were present in the 100-point grid. Thus, they were successful in detecting extremely rare species most of the time using the 50-point grid. Also, this protocol includes the recording of all species present in a plot whether they are 'hit' or not, and therefore the presence of these species will be recorded. In statistical analyses point intercept data are converted into categorical data (6 categories equivalent to the previously mentioned Braun-Blanquet categories). These data are converted to prevent dominant species from overwhelming the importance of less dominant species in the community analyses.

Groundwater table level is measured in groundwater wells (approximately 60cm long) installed into the marsh surface. Groundwater table level provides information on the

amount of waterlogging or drainage that is occurring in a marsh. Water table level is an important parameter to use when attempting to understand why vegetation is changing, as plant species differ in their relative tolerance of extreme water/salinity conditions and their relative ability to compete in different water regimes. It is recommended that a groundwater table level well be placed in association with each vegetation sampling plot.

In addition to water table level, soil water salinity is an important factor controlling the patterns of salt marsh vegetation. A soil probe is recommended for collecting soil salinity. It is not appropriate to sample soil water salinity from water within the groundwater wells for several reasons. First, most useful measurements will be from the portion of sediment that has the most active roots and rhizomes. This is generally from the marsh surface to 10-15cm deep. Secondly, groundwater wells integrate soil water from the surface to depth (approximately 60cm) and therefore do not best represent the plant rooting zone. Third, water collected within the groundwater wells tends to stratify over-time, with denser high salinity water near the bottom of the well and fresher water near the surface of the well. The well could be pumped dry before each sampling event, allowed to fill, and then the water in the well sampled for salinity; however, the process of filling could take several hours (although filling is quite rapid for some wells, depending on soil porosity).

Height of key species, such as *Phragmites australis*, is measured within the vegetation plots where the species occurs. Height of *Phragmites* should only be done after the plants have produced a seed head and is measured to the tallest portion of the plant, such as the leaves (when stretched out over head) or the top of the seed head. If there are 20 or fewer stems within the plot, then all stems are measured. If there are more than 20 stems within the plot, then the height of all stems within a randomly selected quarter of the vegetation plot are measured.

Field personnel

Two field technicians can efficiently conduct the vegetation sampling. One person performs the point intercept method and the other transcribes the data. If the visual cover estimate method is used then two people are REQUIRED to conduct the vegetation survey. Each person estimates the cover individually to themselves and then both parties agree on the percent cover estimation.

Salt marsh vegetation sampling and height of key species should take place after the peak vegetative growth has occurred but before vegetation senesces for the winter. Since sampling 20 vegetation plots should take a team of two field staff only one or two days per marsh. Since salt marsh vegetation is only monitored at the end of the growing season (July through September), it is possible that technicians responsible for vegetation monitoring can assume other duties (*e.g.*, salt marsh nekton monitoring), if scheduling is carefully mapped out prior to the sampling season. For example, during the initial testing phase of this protocol we used the same technicians to monitor salt marsh vegetation and nekton at all sites each summer.

Sampling groundwater table and soil salinity should take place every 7 to 10 days throughout the growing season, and should measured within 2hrs of low tide. Sampling 20 wells and plots for water table level and soil salinity can be completed in a couple of hours by one person, so the time involved is not lengthy, however, a schedule to sample these associated parameters should be made in advance to insure that data are collected every 7 to 10 days.

Preparation prior to field sampling

Prior to the field season, all sampling gear should be checked and repaired if necessary. All electronic equipment (*e.g.*, GPS, refractometers) should be calibrated and tested prior to sampling in the field and field personnel should be trained to use all equipment. A complete reconnaissance of field sites should be made at several different tidal stages so that information on tidal cycles, flooding regime, and site geography can be documented and a schedule can be developed. Sampling stations (for vegetation plots and groundwater/salinity monitoring) should be located and marked in the field prior to the first sampling. Maps of the sampling site should be made prior to sampling. The maps should have all station locations clearly marked. If boat access is required to reach sampling sites, arrangements should be made well in advance of the first sampling.

Groundwater wells need to be constructed and installed prior to the start of the growing season (e.g., before May). Since the location of groundwater wells will be permanent, in subsequent sampling seasons the wells just need to be located and replaced if cracked or missing.

Conducting sampling

Once the sampling schedule has been arranged, sampling is relatively easy. This protocol urges that two or more teams of two people be used for sampling efficiency and safety reasons, although one team of two people can accomplish sampling.

Vegetation plots are located in the field and the $1m^2$ plot is laid down on the marsh surface. Vegetation plots are offset from the plot stake (usually 1m to the right in the direction of the transect when facing higher plot numbers) to prevent trampling. All species within the plot are recorded on the data sheet. For the point intercept method, a meter stick is placed on the marsh surface and 5 dowels with marked increments (10 increments spaced 11.1cm apart) are placed perpendicular to the meter stick at 0, 25, 50, 75, and 100cm intervals along the meter stick, so the $1m^2$ plot is divided into a grid of 50 evenly spaced points. A thin rod ($\leq$3mm) is held vertical to the first sampling point and lowered through the vegetation canopy to the sample point on the ground. All vegetation species and other cover types (*i.e.*, water, bare ground, *etc*.) that touch the rod are recorded as a "hit" on the data sheet for that point. The process is repeated for all remaining points within the plot until all 50 points have been sampled.

For the visual cover estimate method, the vegetation plot is located as described above. All species and other cover types (*i.e.*, water, bare ground, *etc*.) within the $1m^2$ plot are recorded on the data sheet. For each listed species and cover type each observer individually decides the cover class category. Once each sampler has come to an

estimate, they speak the estimate out loud. If the estimates are the same then the visual cover class is written on the datasheet. If the estimates are different then the samplers re-evaluate their estimate until they come to an agreement on the cover category for the species or cover class. The method is repeated for all species and cover classes within the plot.

For both methods, voucher specimen(s) of any unknown or plants with questionable identification should be retained in clearly labeled plastic bags with the plot number and unique identifying number (*e.g.*, Plot 1-40, unknown #1) and transported back to the laboratory for positive identification.

Height of key species (in flowering condition) is measured at the time of vegetation sampling. Within each vegetation plot the height of all stems within a randomly selected quarter of the vegetation plot are measured. If there are fewer than 20 stems per plot than all 20 stems within the plot are measured.

Groundwater table level is sampled every 7 to 10 days throughout the growing season within two hours of low tide. To measure groundwater table level a meter stick is inserted into well (0mm end first) until the meter stick barely touches the water surface. The measurement from the top of the water to the top of the well is recorded. The measurement from the height of the well from the marsh surface is also recorded. The height of the well from the marsh surface is subtracted from the total distance of the top of the well to the water level giving the distance of the water level below the marsh surface.

Soil water salinity sampling should coincide with groundwater well sampling and is always measured within 2hrs of low tide. Soil salinity is taken adjacent to the vegetation plot or ground water well. The soil salinity probe is inserted into the soil (crimped end downward) 15cm into the sediment. The plunger is withdrawn and the salinity of the water within the syringe is measured after being filtered.

Data Management

Data should be entered into the Northeast Coastal and Barrier Network Monitoring Program Salt Marsh Database (Access software program) as soon as possible after collection. Any unknown specimens should be identified immediately upon return to the laboratory and the correct identification indicated on the field datasheet. Any edits, changes, or corrections to the data should be noted on the field data sheet and include the date and person (initials) verifying the change or correction. All GPS coordinates should be entered into a GIS program (*e.g.*, ArcView) to verify the locations of sample plots.

Analysis and Reporting

Data collected from salt marsh vegetation monitoring should be summarized yearly by each monitoring site. Local and regional analyses should be conducted and trend reports completed at 5 year intervals and include all data and all parks monitored to date. All data are stored in an Access database (Northeast Coastal and Barrier Network Monitoring Program Salt Marsh Database) and reports can be generated from this database.

Additional summaries and analyses for trend reports may require the export of data from the Access database into other programs.

Data Summaries and Statistical Analyses

Routine data summaries for vegetation data include species composition (species lists) and percent cover for all cover types per site that have been generated from the point intercept or visual cover estimate data (Table 1).

When data exist from more than one site or more than one sampling year, statistical analyses will be conducted to determine if salt marsh vegetation community structure is different between sites or changing over time. Community data analyses that we often use are part of the PRIMER software package (http://www.primer-e.com; Carr 1997) that use non-parametric tests to detect differences in community structure. Non-parametric permutation testing procedures can be effectively used to evaluate dissimilarity or similarity in salt marsh vegetation communities between marshes or between sample years. In the typical analysis we use the ANOSIM (Analysis of Similarities) to determine if there are differences in community structure either among years or between sites, followed by a calculation of the contribution the individual cover types or species to the observed dissimilarity. Prior to analyses in ANOSIM point intercept data are converted to categorical data equivalent to the Braun-Blanquet scale (0: absent; 1:<1%; 2:1-5%, 3:6-10% 4: 11-25%; 5:26-50%, 6:51-75%, 7:76-100%).

Ancillary data (groundwater table level and soil salinity) should also be summarized by each sampling site. Summaries should include means (replicates are the stations) and an estimate of error. Figures 1-18 and 1-19 are examples of the type of data summaries for groundwater table level and soil salinity for three marshes within the Long Island Complex National Wildlife Refuge over a three year period. Once two or more years of data have been collected groundwater and soil data can be analyzed using an Analysis of Variance (ANOVA) to determine if groundwater table or soil salinity has changed over time. Height of key species, such as *Phragmites australis*, should be averaged by plot (each plot with the species is a replicate), and then all plots with the species present averaged per each site. Each average should be accompanied by an estimate of error, and an ANOVA can be used to determine if average height is changing over time.

Data should be entered into a data management program as soon as possible after collection. Any unknown specimens should be identified immediately upon return to the laboratory and the correct identification indicated on the field datasheet. Any edits, changes, or corrections to the data should be noted on the field data sheet and include the date and the person's initials verifying the change or correction.

Reporting Schedule

Reports presenting monitoring information for parks that were sampled, data summaries, statistics (if applicable), and any problems or special circumstances/events that were encountered will be reported annually and submitted to the each park's Natural Resource Manager and the NCBN coordinator (Bryan Milstead, Bryan_Milstead@nps.gov). Reports should be generated in a timely fashion and be submitted no later than the spring

following the monitoring season (*e.g*., monitoring for summer 2004 should be reported by May 2005).

A trend analysis report will be generated for every 5 years of data. This is a comprehensive report that includes a Network and regional overview of the monitoring program, management plans, summaries of all data to date, statistical comparisons among years (if appropriate), any concerns or problems, and suggestions to improve or augment the existing monitoring program. The first trend report is due in 2008 and will include all data collected from 2003 to 2007, the next trend report would be due in 2013 and would include all new data from 2008 to 2012 as well as a trend analyses (*e.g*., ANOSIM) for the entire dataset, with all subsequent reports following this same timeline. The most important component of the trend report is the analysis of the long-term monitoring data for each site and park. Trend analysis reports are submitted to each park's Superintendent, and Natural Resource Chief and the NCBN coordinator (Bryan Milstead, Bryan_Milstead@nps.gov).

Operational Requirements
Operational requirements for the implementation of the salt marsh vegetation protocol include a schedule for park units and sites, staff to conduct sampling and oversee the monitoring, data analyses, reporting, and funds for supplies and travel expenses.

Personnel
Two people are required to sample salt marsh vegetation, and two teams are recommended. It is useful to have one field sampling leader. This person can instruct other personnel on what needs to be done prior to and during the sampling season as well as making sure that all equipment are in working order and that data are correctly recorded. In the field, one person performs the point intercept method and the other transcribes the data. If the visual cover estimate method is used then two people are REQUIRED to conduct the vegetation survey. Each person estimates the cover individually to themselves and then both parties agree on the percent cover estimation. Typically, a team of 2 who are knowledgeable in plant identification can sample 20 vegetation plots in 1 or 2 days. It is strongly urged that project staff seek assistance and establish a working relationship with experts to assist with the identification of plant species.

Monitoring groundwater table level and soil salinity requires more time. Wells should be established or checked prior to the sampling season. Data should be collected every 7 to 10 days throughout the growing season (May through September) in the northeast. Although it only takes one person approximately 1 to 2 hours to collect data from 20 wells and soil salinity sites, this needs to occur approximately 16 to 25 times through out the summer. One person can collect groundwater table and soil salinity, but 2 people should be used for safety purposes. Collection of data is straight forward and no extensive training or prior experience is necessary.

All personnel should be physically fit, able to spend long hours in field conditions (*e.g.*, hot, humid weather), and able to carry field equipment.

Scheduling

The implementation schedule for NCBN and selected parks within the NETN is presented in Table 1-2. During the testing phase of the salt marsh vegetation protocol 3 to 5 park units (each with 1 to 3 study sites) were sampled each year by a crew of 4 field technicians. Additionally, these technicians also were able to collect nekton data as part of the salt marsh monitoring program. One supervisor oversaw the testing phase and was responsible for obtaining research permits, maintaining contact with each park's Natural Resource Manager, overseeing data collection, data quality control, data entry, analyses, and reporting.

The salt marsh vegetation protocol should be implemented every 3 years at each specific long-term monitoring site. After the testing phase in 2003 – 2005, parks are sampled every 3 years.

Testing of the salt marsh vegetation protocol started in 2003. We tested both the salt marsh vegetation and nekton protocols at the same time, and thus the field crew was responsible for collecting both vegetation and nekton data. Vegetation was sampled in July, while nekton was sampled in June and August. We found this to be a very efficient, but somewhat taxing for the field crew (primarily due to extensive traveling to and from sites) method for accomplishing both vegetation and nekton monitoring at several sites within one sampling season.

Four people can efficiently sample one site (*i.e*., 20 vegetation plots) in one day. If only 2 people are sampling, the number of sampling days required per site is increased. The benefit of having a dedicated field crew is that there will always be enough help to conduct the sampling. The downside of a dedicated field crew is that for the early part of the summer (June), there may be little for them to do as the plants within the marsh may not have matured enough for accurate identification. However, if groundwater table level and soil salinity are monitored, these parameters are sampled throughout the growing season by the technicians, but there may still be some down time as a marsh can be sampled in one day for these parameters.

Technicians could be shared among parks that are in the same geographic region (*e.g*., ASIS, COLO and GEWA or FIIS, GATE and SAHI), especially if both the vegetation and nekton protocols are implemented at the same time. If this is done, these technicians must be dedicated to the sampling for the monitoring protocol(s) in order to effectively monitor all sites. Four technicians (2 teams of 2 technicians) can sample more sites, and this is an option if more than one park within the same geographic region is monitored within the same year. The technicians could be shared among the parks thus accomplishing monitoring at several sites within one year. If only the vegetation protocol is implemented then sharing technician among parks may still be feasible. However, vegetation must be sampled at the end of the growing season and there may be nothing for the technicians to do in the early part of the summer. Groundwater wells can be installed early in the summer and groundwater data can be collected by the technicians (but this only requires 1 or 2 days every other week) or they may be allocated to other

duties for the first part of the summer. This may be a more cost effective method than having the technicians located at a central location and traveling to the monitoring sites which can be costly. However, this may require regional oversight of the monitoring program from year to year to ensure adequate supervision training, quality control of the data, and reporting responsibilities.

If key species, such as *Phragmites australis*, are present, height measurements must be done at the end of the growing season after the plants have flowered. This can be done at the time of vegetation sampling if the plants have flowered. If plants have not flowered at the time of sampling then an additional visit is necessary to record height. In Southern New England this would be late August through September.

Budget

The budget for implementation of the vegetation protocol includes the salary for at least 2 full time seasonal (May through August or September) field technicians (GS level 4 to 7, depending on qualifications), although 4 technicians are strongly suggested, and part time salary for one supervisor (approximately GS level 10 or higher).

Sampling equipment for both of the vegetation sampling techniques (point intercept and visual cover estimation) are inexpensive (less than $10) and easy to manufacture. Five dowels (1/4 in diameter and 1m long) are required to make the $1m^2$ plot, and one 1m thin metal rod is required for use as the bayonet.

Groundwater wells are constructed from lengths of PVC pipe and end caps (available from local hardware stores) and cost approximately $2 per well. Soil salinity probes are constructed from stainless steel tubing (we have had success using gas chromatography tubing), which costs approximately $50 for 1m length. Syringes can be purchased from local drug stores for a nominal charge and tubing (*e.g.*, tubing for airstones) can be found at aquarium stores.

Other miscellaneous supplies that are required are hip boots for field personnel (approximately $100 per pair), vegetation identification guides, field notebooks (we prefer waterproof notebooks or waterproof paper for data sheets), clipboards, and oak stakes or flags for marking sampling locations. Having maps of sampling stations, preferably in GIS form, are a great help in setting up and locating stations in the field. Computer and GPS equipment to support the project are also necessary.

If technicians are traveling to several sites then funds must be budgeted for travel expenses and a reliable vehicle must be available for transportation. Occasionally other travel expenses such as vessel time are also required, as in the case of BOHA. As an example, vessel time to and from the islands of BOHA cost approximately $80 per hour (total vessel expense for the 2004 sampling season for BOHA was $400).

Version Control Procedures

This protocol is a revision of a protocol first developed by Roman *et al*. (2001) for use in the Long-term Coastal Ecosystem Monitoring Program at Cape Cod National Seashore.

The original protocol can be found that the National Park Service Inventory and Monitoring website: http://www.nature.nps.gov/im/monitor/protocoldb.cfm

This protocol was revised for the following reasons:

- To conform to NPS format guidelines

Previous Version	Revision Date	Author	Changes Made	Reason for Change	New Version #
Original Protocol	12/7/04	Mary-Jane James-Pirri mjjp@gso.uri.edu	Format Changes	Conform to NPS guidelines	#1

Table 0-1. Percent composition of salt marsh vegetation communities (calculated from average cover of all plots) at Horseshoe Cove, Sandy Hook Unit, GATE . Twenty-one vegetation plots were sampled using the point-intercept method in 2003. Average percent composition calculated from point intercept values, and average Braun-Blanquet score are shown for comparison. Twenty-one vegetation plots were sampled using the point-intercept method in 2003.

Species	**Common Name**	**Percent Composition (average)**	**Braun-Blanquet Value (average)**
Atriplex patula	Spreading orache	1	0.2
Bare ground	Bare ground	22	2.7
Distichlis spicata	Spike grass	1	0.2
Distichlis spicata (dead)	Spike grass (dead)	1	0.2
Iva frutescens	Marsh elder	4	0.6
Iva frutescens (dead)	Marsh elder (dead)	1	0.1
Limonium carolinanum	Sea lavender	<1	<0.1
Salicornia europea	Glasswort	1	0.1
Spartina alterniflora	Salt marsh cordgrass	29	3.3
Spartina alterniflora (dead)	Salt marsh cordgrass (dead)	22	2.8
Spartina patens	Salt meadow cordgrass	4	0.5
Spartina patens (dead)	Salt meadow cordgrass (dead)	2	0.2
Sueada linearis	Sea blite	1	0.2
Water	Water	10	1.2
Wrack or Litter	Wrack or Litter	1	0.2

Table 0-2. Suggested sampling schedule for NCBN and NETN parks. * Indicates that some parks may be monitored more frequently due to special circumstances (*e.g.*, ongoing restoration). Note: GATE, Big Egg Marsh, vegetation currently being monitored by NPS staff.

Year/Park	2003	2004	2005	2006	2007	2008	2009	2010
ASIS			**X**			**X**		
ACAD			**X**			**X**		
BOHA		**X**			**X**			**X**
CACO		**X**			**X**			**X**
COLO	**X**		**X**			**X**		
FIIS	**X**			**X**			**X**	
GATE*	**X**	**X**		**X**			**X**	
GEWA			**X**			**X**		
SAHI		**X**		**X**			**X**	
SAIR*		**X**			**X**			**X**

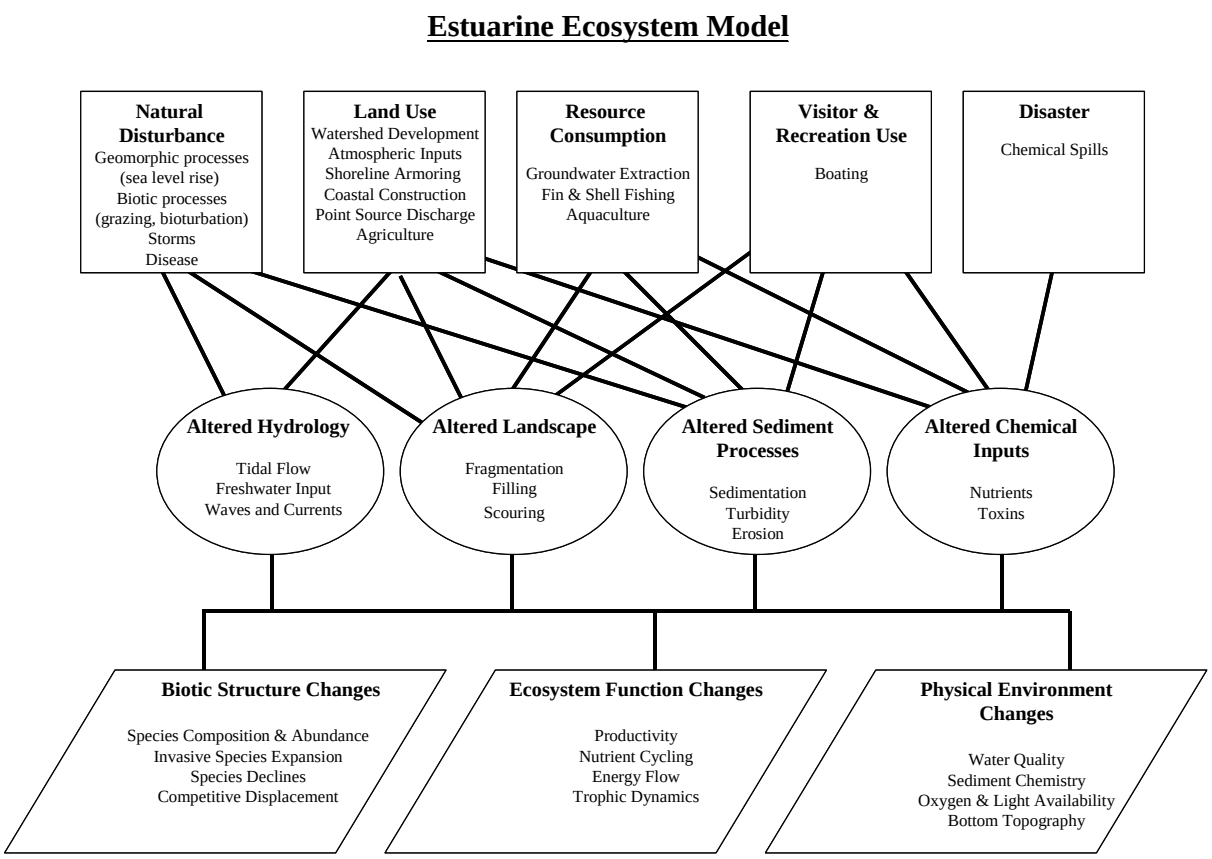


Figure 1. The Northeast Coastal and Barrier Network Estuarine Ecosystem Model.

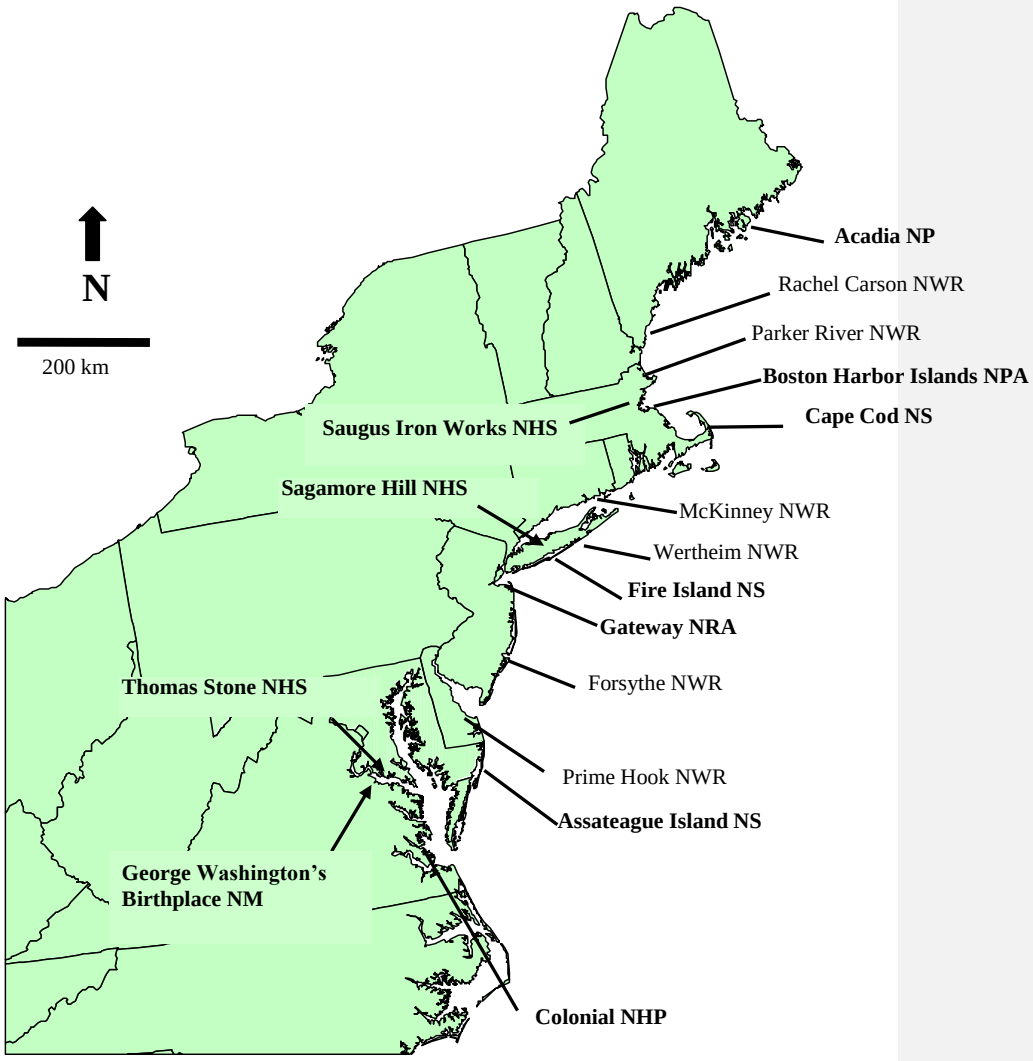


Figure 2. Northeast Coastal and Barrier Network and Northeast Temperate Network National Parks (in bold) and Region 5 US Fish and Wildlife Refuges where the Salt Marsh Vegetation Protocol is either currently implemented or will be implemented in the near future.

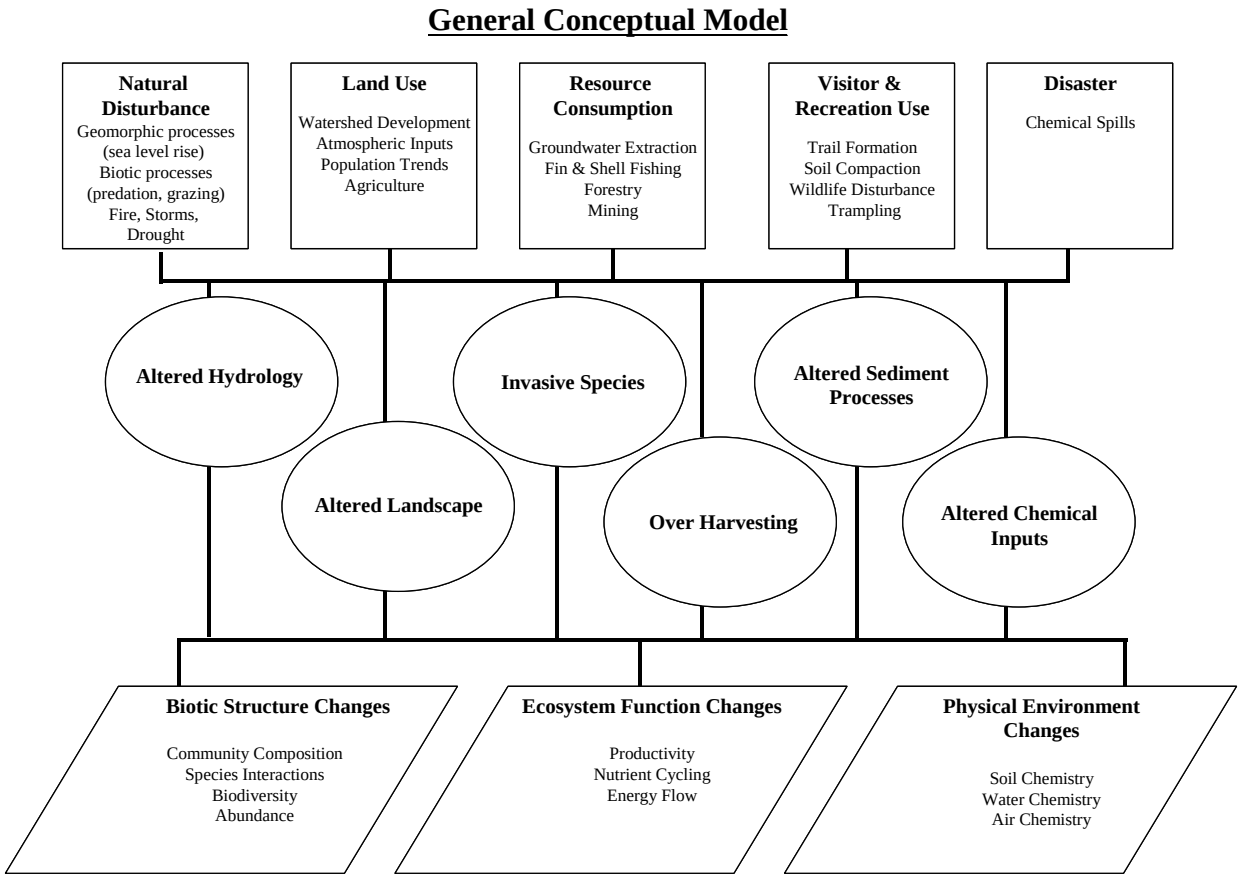


Figure 3. The Northeast Coastal and Barrier Network General Conceptual Ecosystem Model

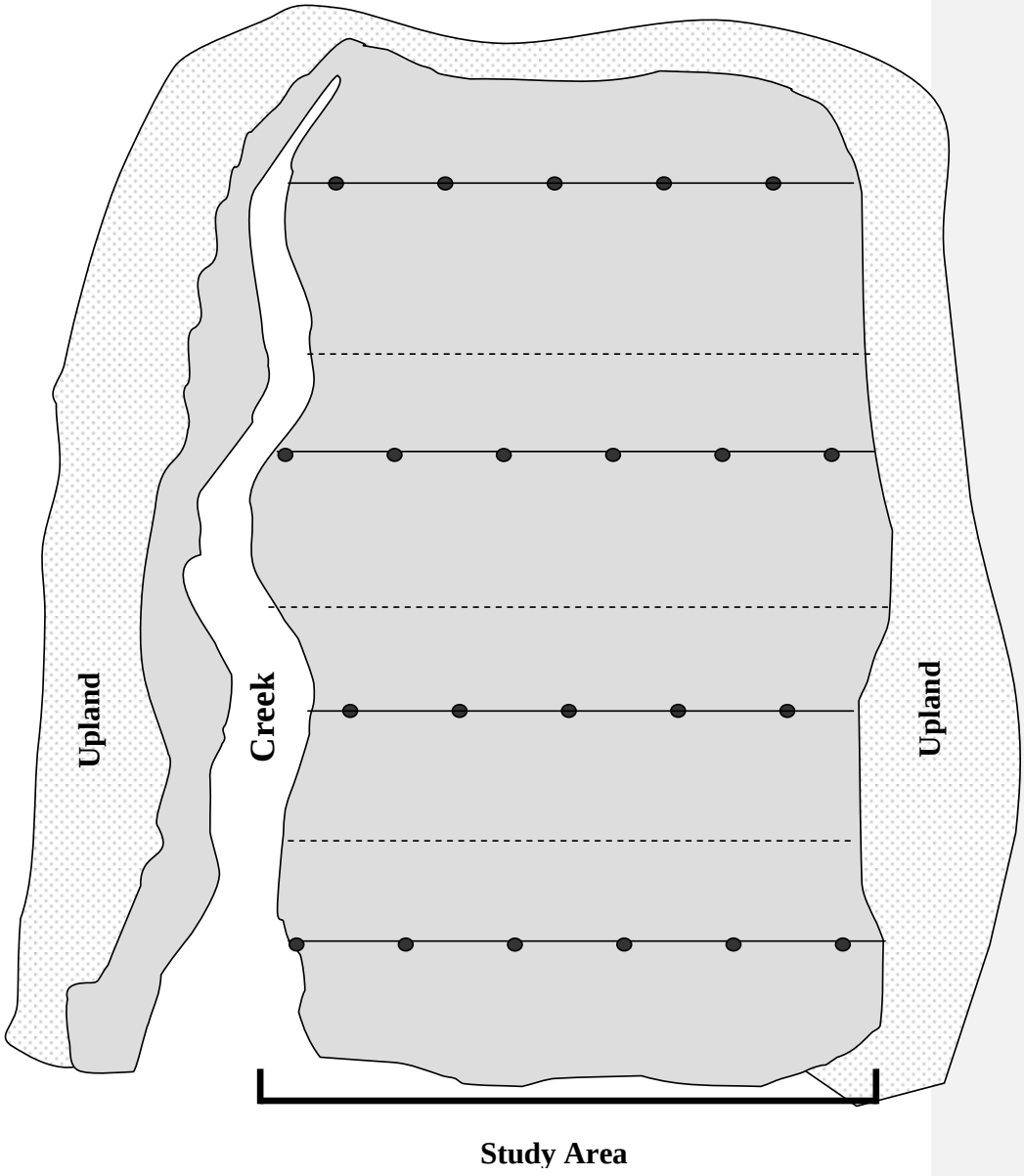


Figure 4. The study marsh is divided into equal-sized sections (indicated by dashed lines) and one transect is randomly located, extending from the creek bank to upland, within each section. Vegetation plots (dark circles) are aligned along transects (solid lines). The first plot (near the creek bank) of each transect is randomly located, and all other plots are then systematically located along each transect. Note that total number of plots per marsh is at least n=20.

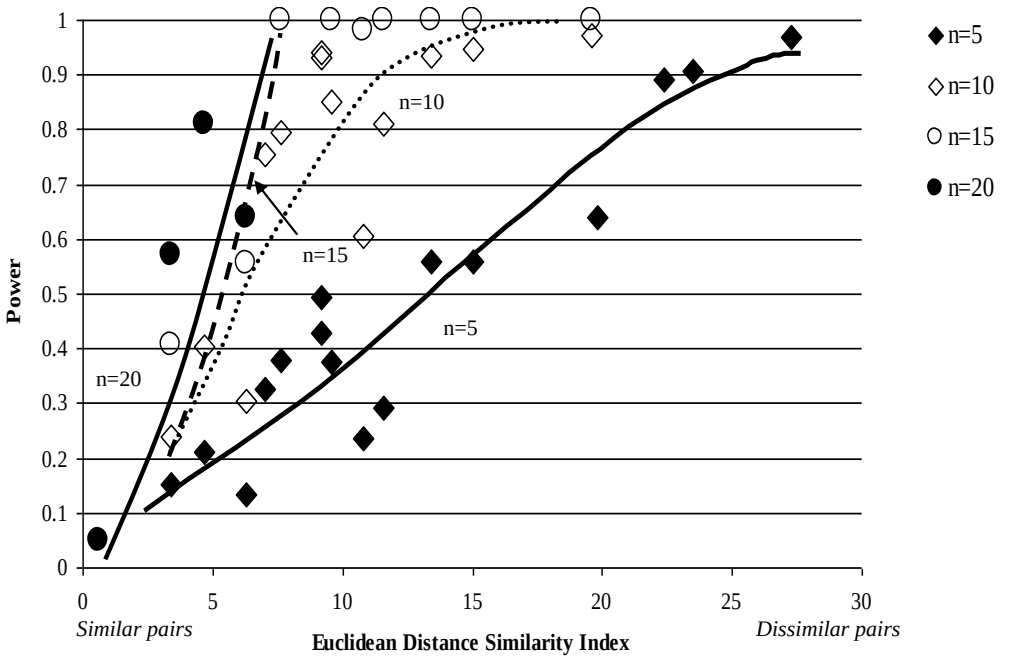


Figure 5. Estimation of power at alpha = 0.05 for 5, 10, 15, and 20 samples per marsh. Distance was calculated by the Euclidean distance similarity index between marsh pairs. Lines were hand drawn to assist in the identification of the appropriate sample size to achieve adequate power for a given similarity distance. Plotted points are pairs of marshes where the null hypothesis of no difference was rejected at alpha=0.05, and had a power of less than 1.0

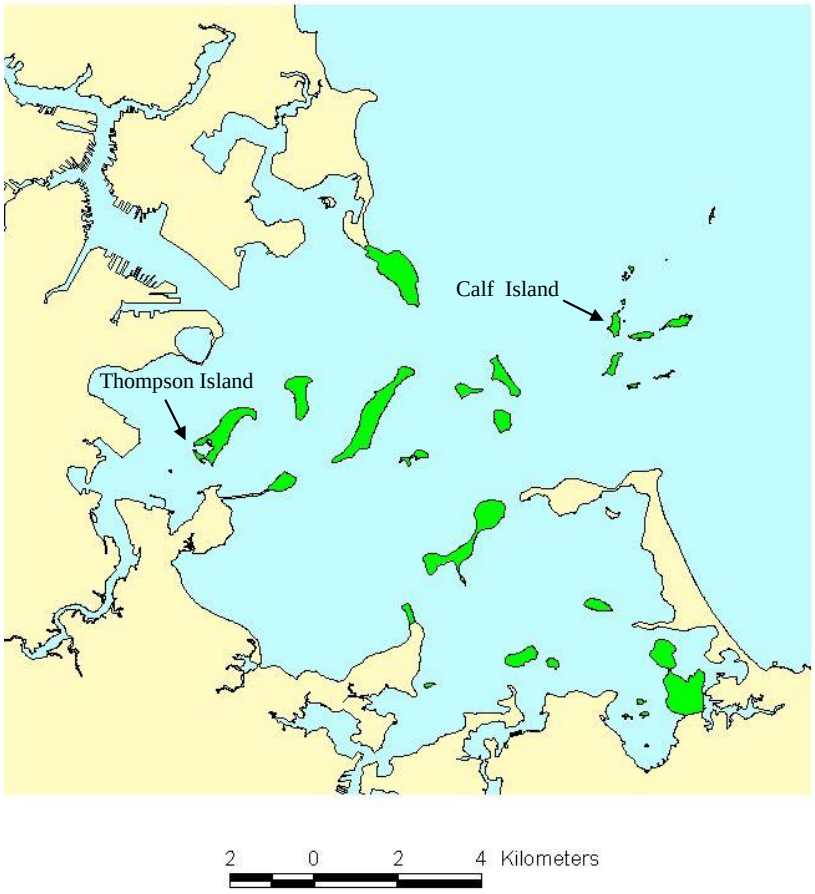


Figure 6. Map of BOHA showing sampling locations.

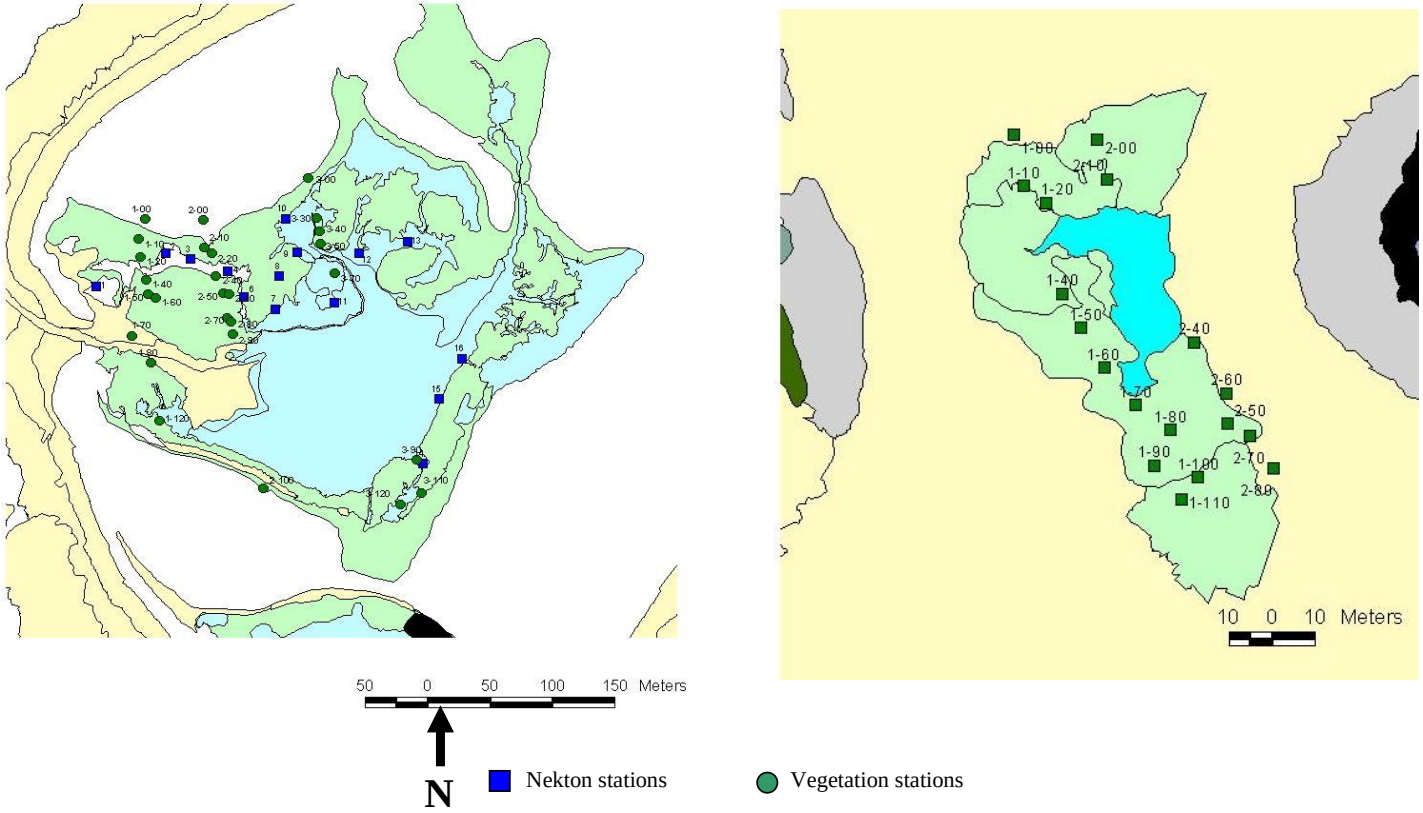


Figure 7. Map showing locations of nekton and vegetation stations sampled in 2004 at Thompson (left) and Calf Islands (right), BOHA.

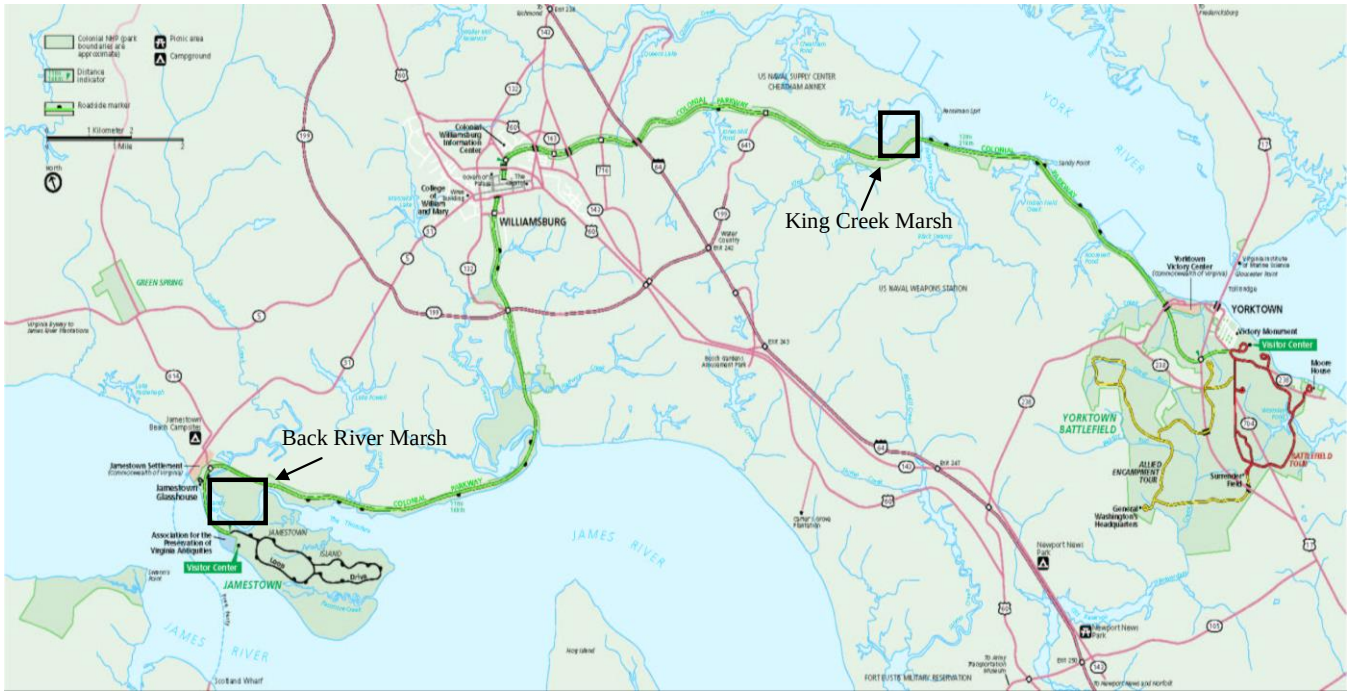


Figure 8. Map of COLO showing sampling locations.

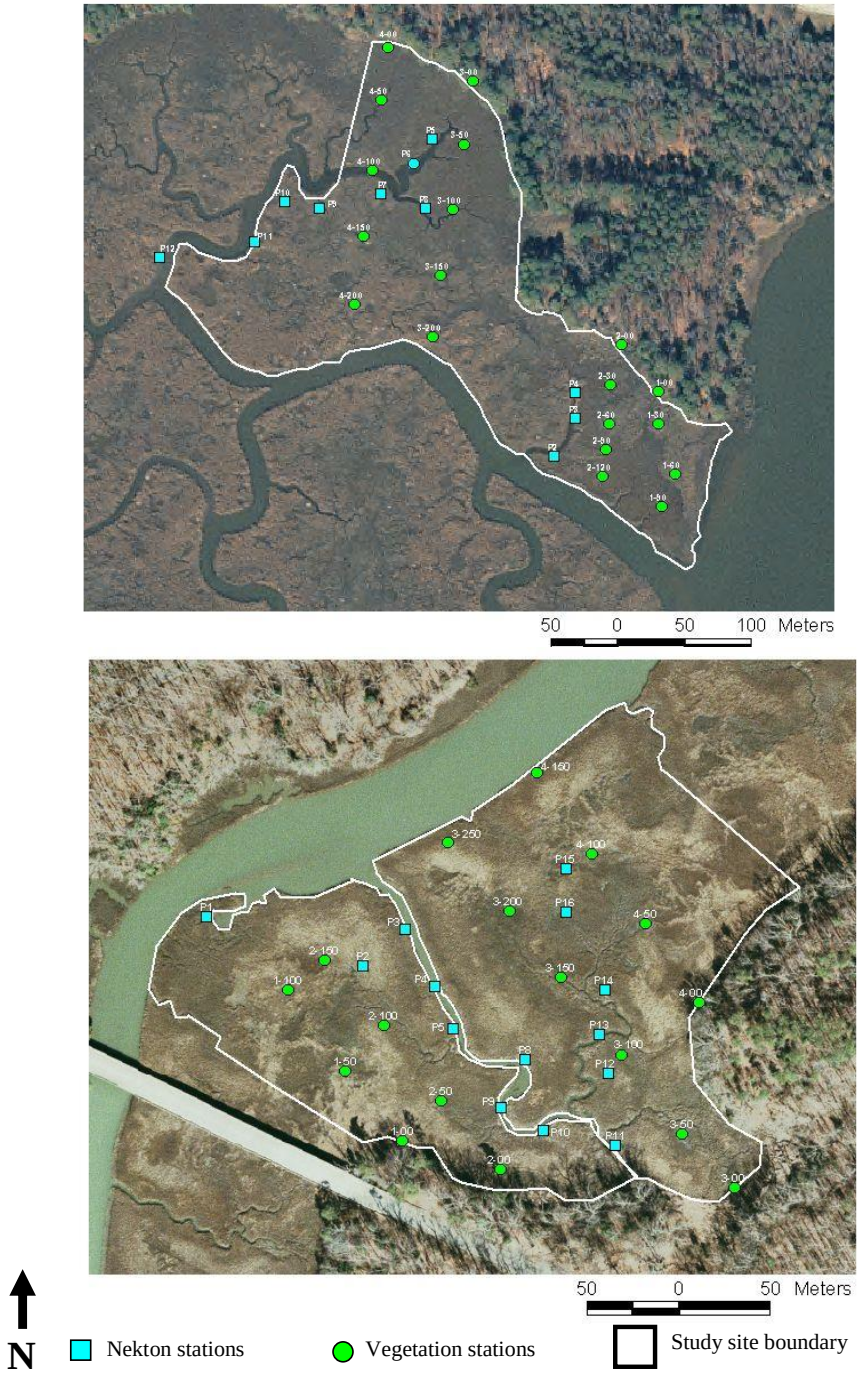


Figure 9. Map showing locations of stations sampled in 2003 for nekton and vegetation at Back River (top) and King Creek (bottom) marshes, COLO.

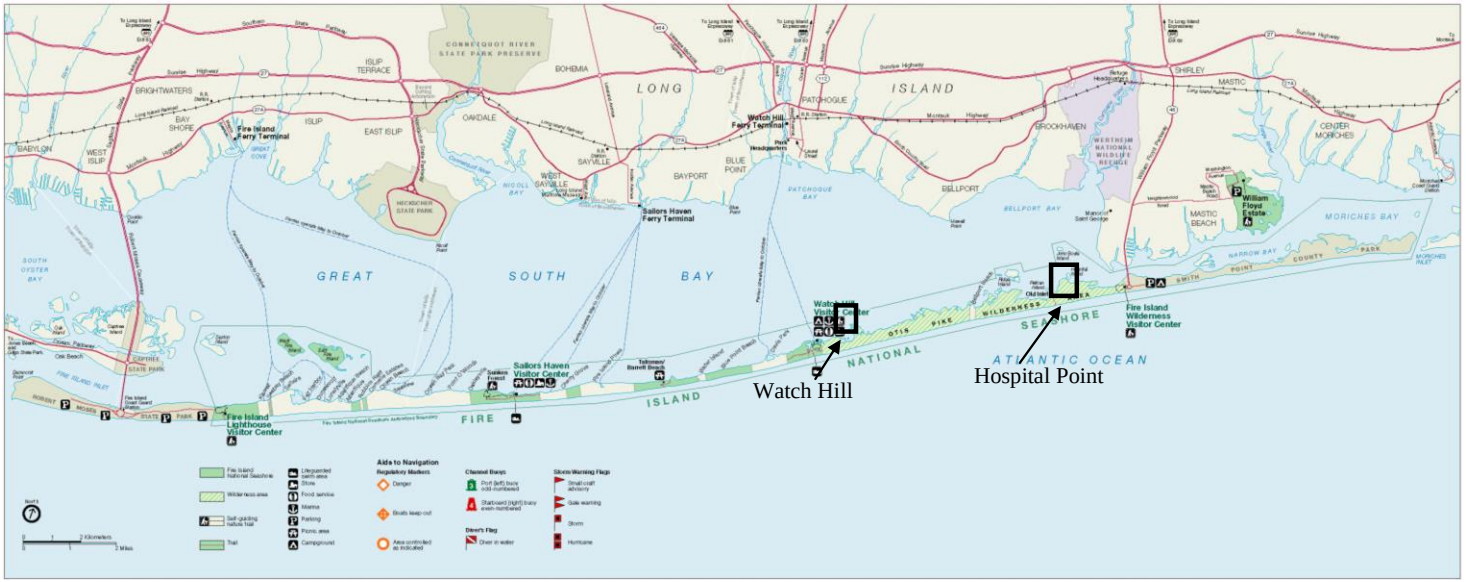


Figure 10. Map of FIIS showing sampling locations.

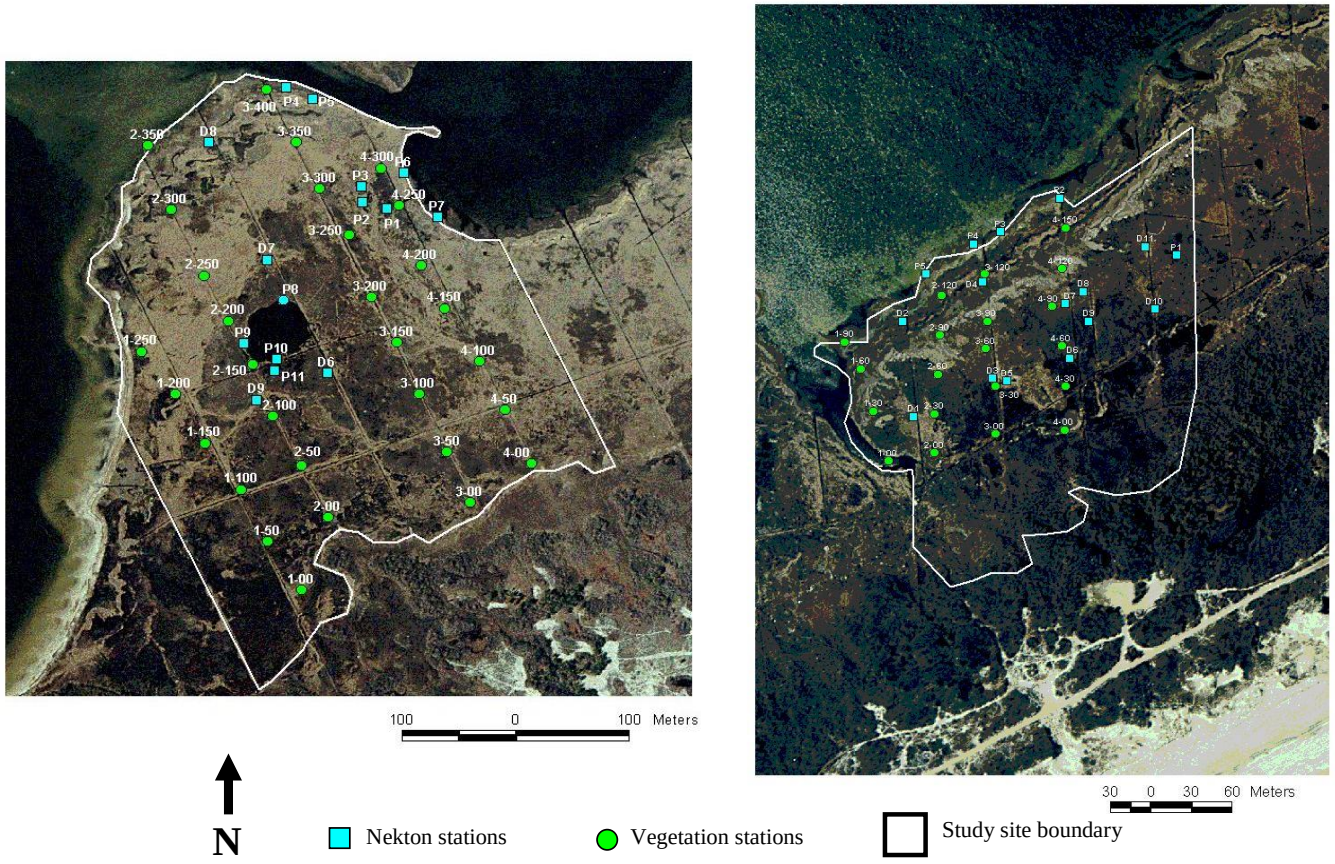


Figure 11. Map showing locations of stations sampled in 2003 for nekton and vegetation at Hospital Point (Left) and Watch Hill (right) marshes, FIIS.

Figure 12. Map of GATE showing sampling location at Sandy Hook Unit.

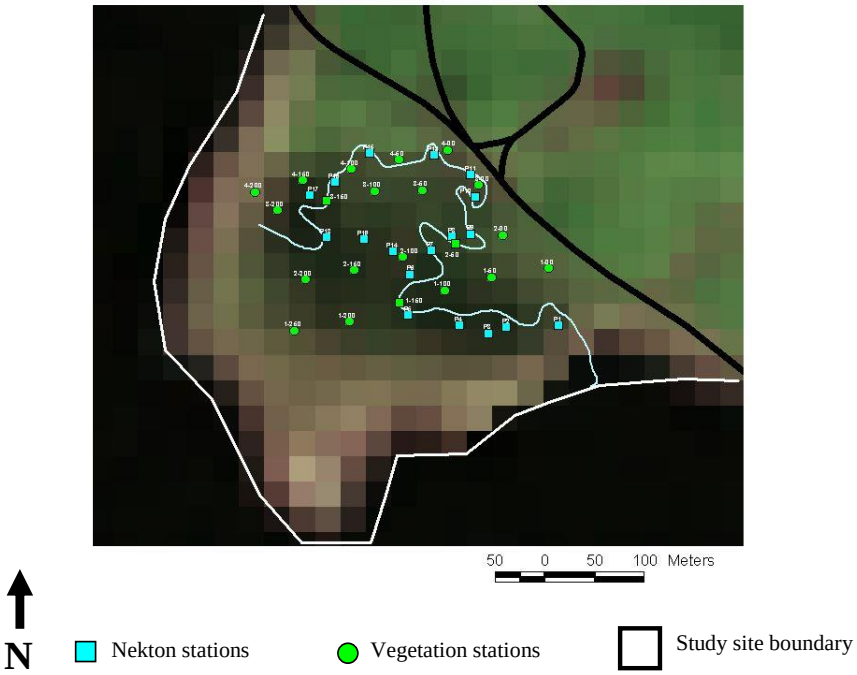


Figure 13. Map showing locations of vegetation stations sampled in 2003 at Horseshoe Cove marsh, Sandy Hook Unit.

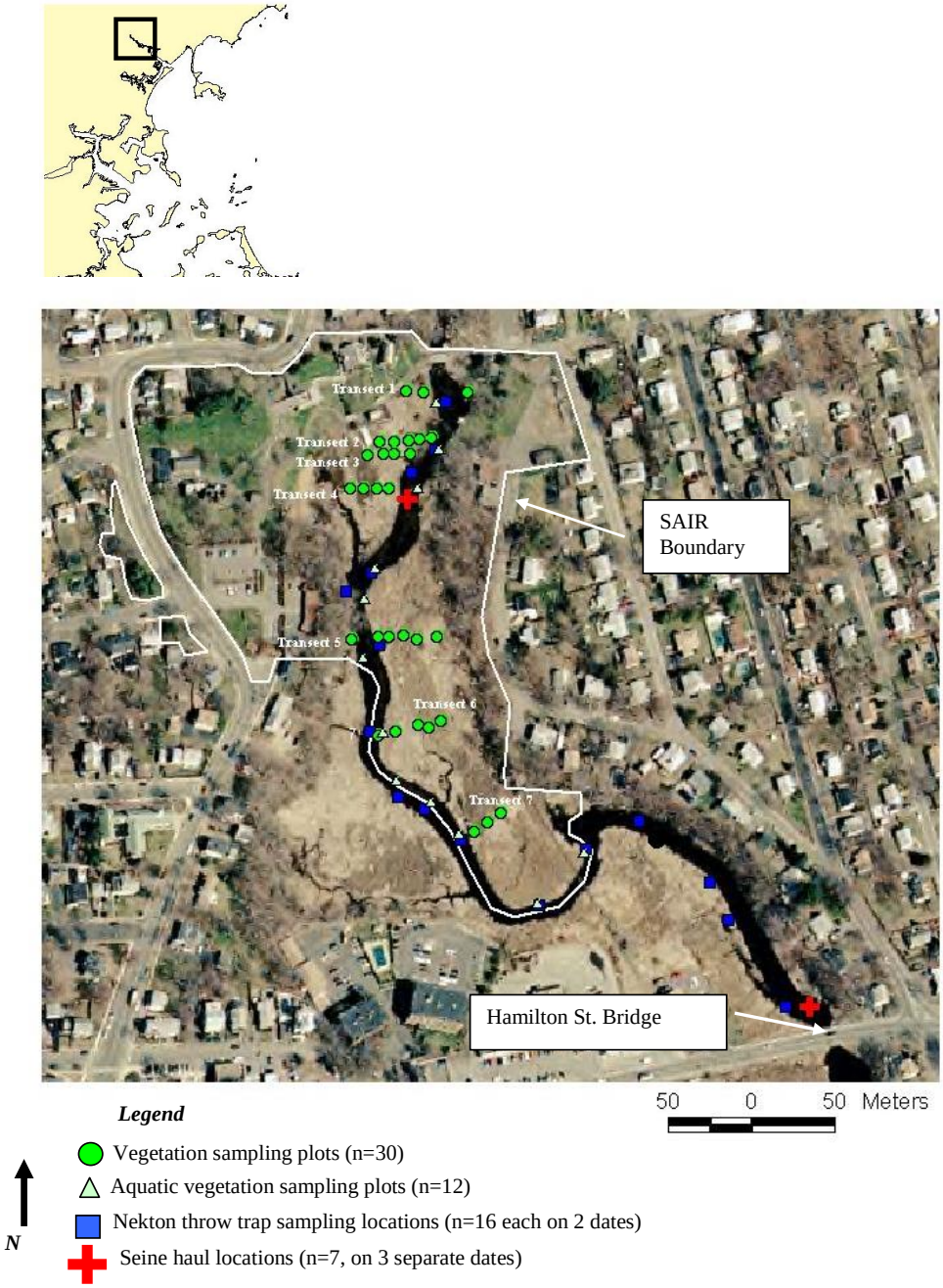


Figure 14. Map of Boston Harbor area (top) and map of SAIR (bottom) showing locations of nekton and vegetation stations sampled in 2004.

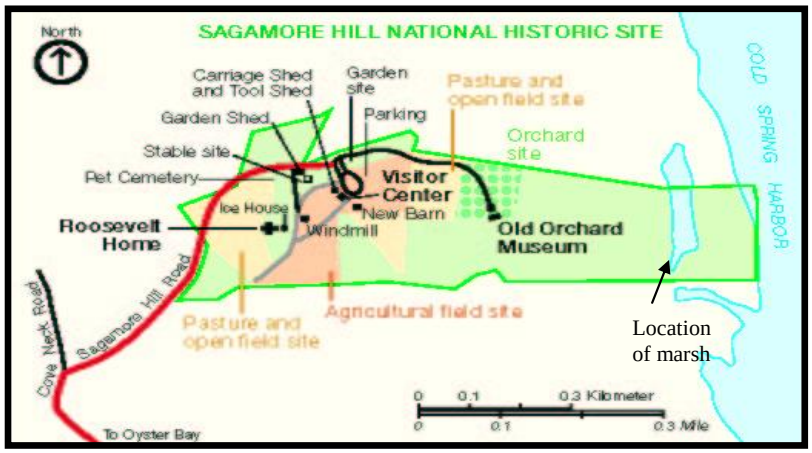


Figure 15. Map SAHI showing sampling location.

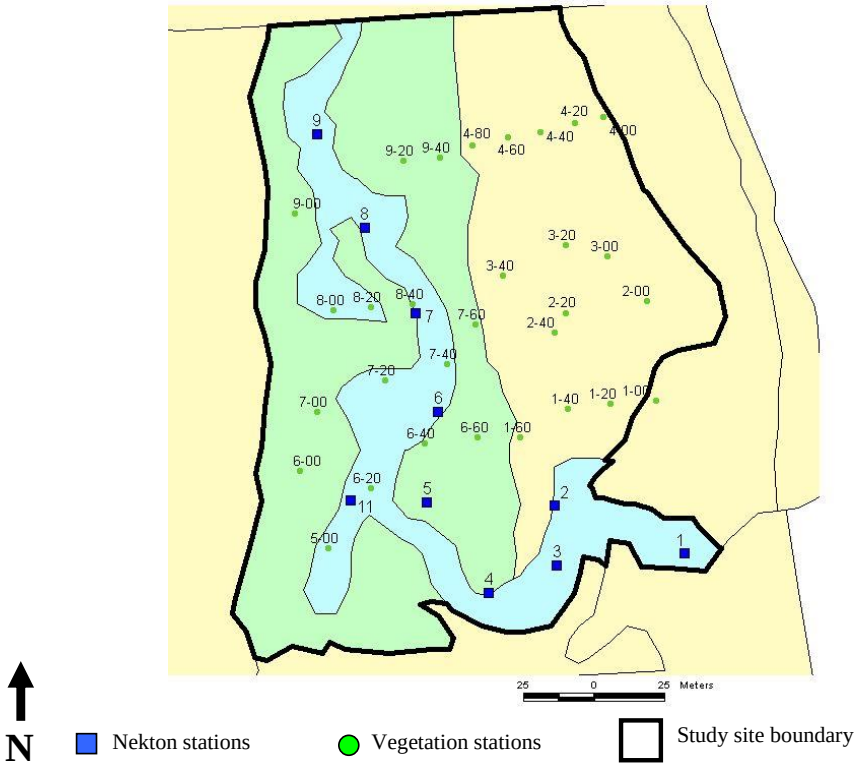
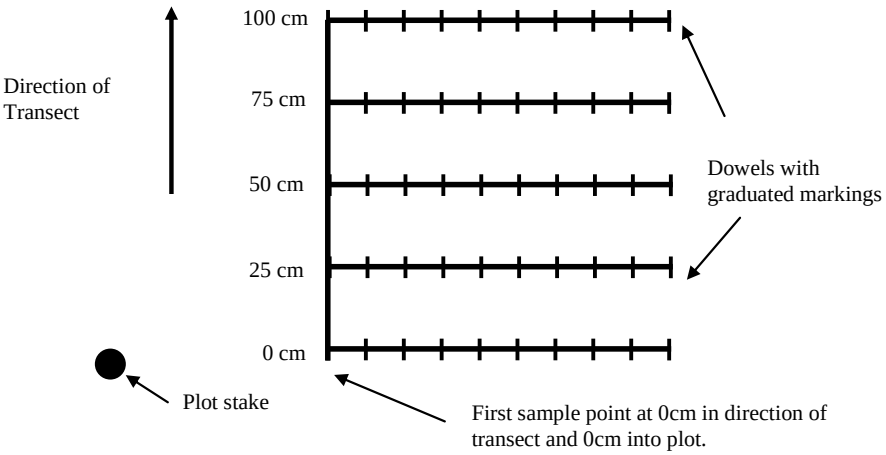


Figure 16. Map showing locations of stations sampled in 2004 at SAHI.



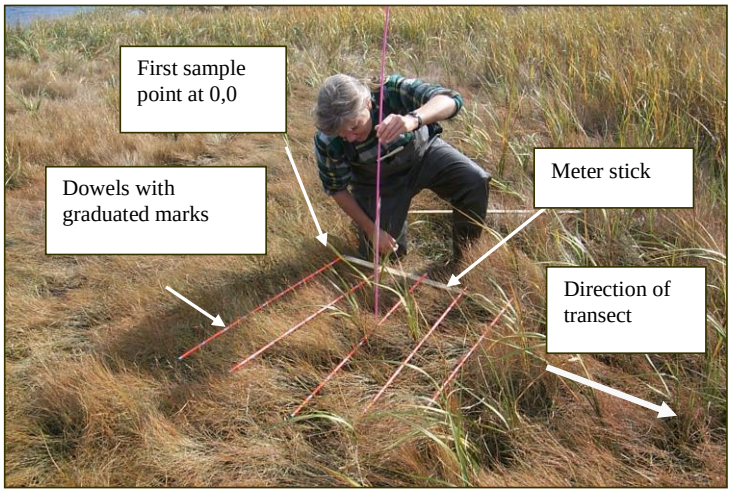


Figure 17. Schematic and photo of a vegetation plot and arrangement of dowels used in the point intercept method

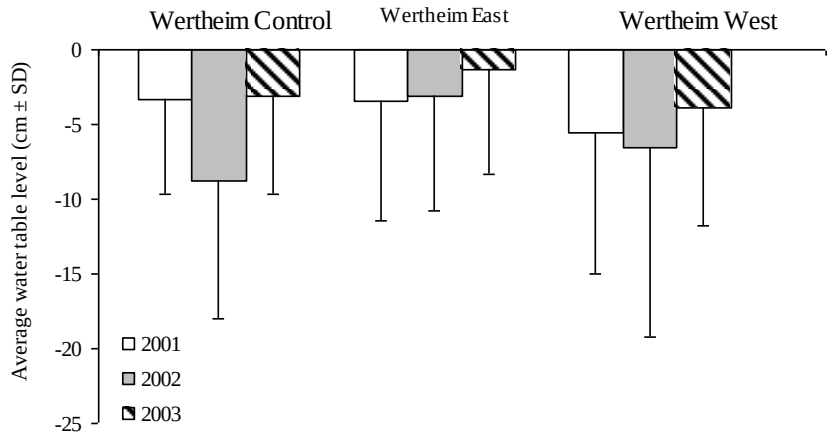


Figure 18. Average water table level, in cm below the marsh surface (±SD) for Wertheim sites, Long Island Complex NWR.

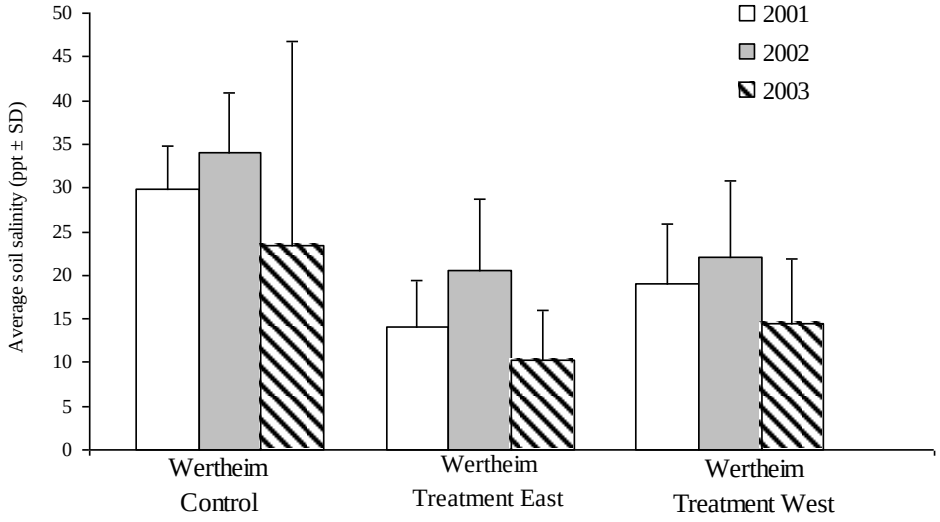


Figure 19. Average soil salinity (ppt ±SD) for Wertheim sites, Long Island Complex NWR.

Standard Operating Procedures (SOP) for Monitoring Salt Marsh Vegetation

1 SOP 1: Selection of Study Site

Study sites will be selected using a stratified random sampling design, if more than two sites are available within the park. If there are fewer than two salt marshes within the park, then either both areas will be monitored or one area will be randomly selected from the two areas.

- To stratify an area of extensive salt marsh, divide the area into equal sized strata such as distance from the inlet (*e.g.* close, intermediate, and far from the inlet).
- Strata should be equal in size.
- Divide each strata into acceptable (e.g. 1 to 7ha) areas.
- Randomly select a study area within each stratum from the available acceptable study areas.
- Considerations for acceptable study areas include:
  - Access to study area
  - Co-location with existing monitoring programs
  - Size (must be large enough to fit the require replicates). We have found that a size of 3ha to 8ha is a manageable study site area, with adequate spacing of replicate vegetation plots. Although we have sampled marshes smaller than 1ha, for example the marsh on Calf Island, BOHA, which is 0.41ha, but it is very difficult to randomly place transects and to get the required number of replicates in areas that are this small

1.1 Existing Sampling Sites

1.1.1 Assateague Island National Seashore

- North End marsh is located at the northern tip of Assateague Island. This area experiences heavy grazing pressure by the island's ungulates (*i.e.*, ponies). In the fall of 2005 SET's will be installed at this location. This site must be accessed by 4-wheel drive vehicle via the beach.
- Moderate grazed marsh is located near Life of the Dunes Nature trail and is accessed from the nature trail parking lot. This area experiences moderate grazing pressure by the island's ungulates (*i.e.*, ponies). In the fall of 2005 SET's will be installed at this location.
- Valentines marsh is located in the southern end of the park near the Pirate Islands. This area experiences low grazing pressure by the island's ungulates (*i.e.*, ponies). In the fall of 2005 SET's will be installed at this location. This site must be accessed by 4-wheel drive vehicle via the beach.

1.1.2 Boston Harbor Island National Park Area

- Thompson Island marsh is located on Thompson Island.
- Calf Island Marsh is located on Calf Island.
- Access to the both marshes is by boat. Transportation is arranged through University of Massachusetts Boston, Division of Marine Operations

(http://site.www.umb.edu/forum/1/Marine_Operations/res/web_site/index.html). Vessel time was charged at a rate of $80 per hour in 2004. The landing craft is the best vessel for transportation as it can discharge passengers closest to the marshes.

1.1.3 Cape Cod National Seashore

- Vegetation monitoring at various sites within CACO has been ongoing since the late 1990's.
- Hatches Harbor marsh is a restoration site that has been monitored for vegetation (using this protocol) in 1997, 2000, 2002, and 2004.
- Herring River marsh was monitored in XXXX as part of a restoration program.
- Nauset Marsh was monitored by park staff in 2004 using this protocol.

1.1.4 Colonial National Historical Park

- Both marshes (Back River and King Creek) can be accessed from either public (King Creek) or National Park Service roads (Back River). Back River can also be accessed by canoe (obtained from the Natural Resource Management Division at COLO).

1.1.5 Fire Island National Seashore

- Both marshes (Hospital Point and Watch Hill) must be accessed by boat during the summer due to piping plover nesting on the back barrier beach that prevents access by 4-wheel drive vehicle. Boat transportation should be arranged (well in advance) through the Natural Resource Management Division at FIIS

1.1.6 Gateway National Recreational Area

- Horseshoe Cove Marsh (Sandy Hook Unit) is accessed via a public road adjacent to the marsh.
- Big Egg Marsh (Jamaica Bay Unit) is currently being sampled by GATE staff as part of a restoration project. Monitoring protocols for vegetation are different than those described in this document.

1.1.7 George Washington Birthplace National Monument

- Both marshes (Pope's Creek and Dancing Marsh) can be accessed from existing trails. The islands within Pope's Creek must be accessed by canoe.

1.1.8 Sagamore Hill National Historic Site

- The marsh at SAHI is accessed via a National Park Service nature trail (approximately 1km walk) to the marsh. A cart is available from Boat the Natural Resource Management Division at SAHI, which makes carrying equipment to the marsh easier. The marsh is only partly owned by the NPS, the northern section (delineated by a chain link fence) is private property. Since the property owner has not given permission to sample on his property, sampling must only occur on NPS property.

1.1.9 Saugus Iron Works National Historic Site

- Access to the marsh is by the parking lot in the maintenance area of SAIR. Natural Resource Management Division at SAIR will provide access to this locked area.

2 SOP 2: Establishing Vegetation Sampling Locations

2.1 Randomly Locating Vegetation Transects within the Study Area

- Systematically divide each study area into sections to adequately sample the marsh. The marsh is divided into sections to insure dispersion of the vegetation plots throughout the study area. Usually, a study area is sectioned into 3 or 4 similarly sized areas.
- To section the marsh, measure the axis of the marsh that is parallel to the tidal creek or upland. Divide the marsh into 3 or 4 similarly sized areas.
- Randomly locate one or two transects within each section. Transects should be at least 10m apart. Transects should traverse the main gradient (*e.g.*, elevation) from creek bank to upland edge of the marsh. The starting point for each transect is randomly located along the creek bank. The random location of the starting point for each transect is selected by measuring the total distance of the creek bank (within each section) and then randomly selecting points along the bank where each transect will start. These measurements are best done from aerial photography. For example, if the marsh is divided into 3 sections and each section 75m wide and it has been decided to place at total of 6 transects within the marsh, randomly select a 2 numbers between 0 and 75 for the location of the first 2 transects; then randomly select 2 numbers between 76 and 150 for the next 2 transects; and finally select 2 random numbers between 76 and 225 for the last 2 transects. The random numbers correspond to the distance along the tidal creek (or upland) where each transect will be placed.
    - Transects are drawn perpendicular to the marsh width at these distances.
    - Transects are drawn (in GIS or manually on a map) and their length is estimated.
    - If the tidal creek bisects the marsh, transects should run perpendicular to the creek with plots on either side of the creek.
    - If the marsh is grid ditched, orient transects so that they run across the ditches rather than run parallel to the ditches. This is done to prevent an over abundance of vegetation plots from being located in the same type of habitat such as low marsh near ditch edges.
- There is no definitive number of transects that should be established per marsh, however each transect should be at least 10m apart, to maintain independence of the replicate plots. If random numbers for transect location are closer than 10m, re-select new random numbers. Transects be dispersed throughout the study areas to ensure that the vegetation plots are representative of the entire study area.
- The minimum number of plots (combined along all transects) within each study area must be at least 20. If there are fewer, then the above process must be repeated using different sized sections until the required number replicates is achieved.
- All transects within a marsh should be parallel to each other (*i.e.*, should run along the same compass heading), if possible.

2.2 Location of Vegetation Plots Along Transects

- Locate vegetation plots along each transect. Regardless of the size of the area a minimum of 20 plots are required for each study area.
- Determine the 'plot distance' for the marsh (the distance between adjacent plots). The plot distance should be 10m or greater and is dependent on the length and number of transects required to achieve the minimum replicate size of 20 plots. Since not all transects will be the same length, a guide to determine plot distance would be to add all transect lengths together and divide the total by 23 or 25. This ensures there will be at least 20 replicate plots within the marsh, with a few extra plots in case some plots do not fit on the transect when located in the field.
- The first plot of a transect should be located adjacent to the tidal creek. Plots along transects should traverse the main gradient (*e.g.*, elevation) from creek bank to upland edge of the marsh.
- If the transects cross a large tidal creek, the first vegetation plot on either side of the creek is randomly located within the distance chosen for the distance between plots.
- The first plot of each transect is randomly located by selecting a random number between 0 and the specific plot distance (see above) for the marsh. For example, if plots are spaced 15m apart, then the first plot is randomly located within the first 15m of the transect by selecting a random number between 0 and 15.
- After the first plot is located, all subsequent plots are then systematically placed, along the length of the transect, at the pre-determined plot distance. The spacing of plots along each transect will be variable depending on the area of the marsh. For example, if the marsh is 7ha and divided into 4 sections with one transect randomly located within section, there will be 4 transects, and a 40m spacing between plots along each transect would be appropriate. For smaller marshes, 20m spacing between plots may be necessary. However, all plots should be at least 10m apart to maintain independence of the replicate plots. Each plot should be marked with stakes labeled clearly with transect and plot number.

2.3 Marking Vegetation Sampling Locations

- Locate the beginning of each transect. This can be done using maps of the study area or GPS coordinates generated from GIS programs.
- Oak stakes (1m in length, 2.5cm square) are a good marker, bio-degradable, and readily available from local hardware stores. Station numbers should be indicated on the oak stake with a permanent marker (which will need to be remarked every season) or burned into the wood (branded). Colored flagging can be attached to the stakes to make them more visible in thick vegetation.
- 2 stakes, one at each diagonal of the vegetation plot, should be used to mark the plot. 2 stakes ensures that the plot will be re-located in the exact sampling position (i.e. orientation) in subsequent sampling years.
- Oak stakes will need to be re-marked every year.
- Groundwater wells (if monitored) can be used in place of one of stakes marking the diagonal vegetation plot.

- Vegetation plots should be located and marked in the field prior to sampling. Often laying out transects across marshes is time consuming an can take an entire day, so it is advisable to plan at least one day for locating sampling plots.
- Vegetation plots are numbered with the transect number and distance along the transect. For example, 1-00 would be the first plot on transect 1, 1-20 would be the second plot on transect 1 located 20m from the first plot, 1-40 would be the third plot on transect 1 located 40m from the first plot.
    - Numbering follows the same convention with plots closest to the creek labeled X-00 (X for transect number), with the exception that an "A" or "B" designation is used to differentiate the different sides of the creek. Therefore the plots directly adjacent to the creek, but on opposite sides would be labeled XA-00 and XB-00, if the spacing is 20m the next plots in line on each side would be XA-20 and XB-20, *etc*. Be sure to note which letter corresponds to which side (north or south, east or west sides of the creek) (Fig. 2-1).
    - If the transect crosses a small body of water such as a pond, continuing numbering the plots in sequence. It is acceptable for a plot to be located in a body of water. The percent cover will simply be 100% water.
    - If the transect crosses a large body of water where it is logistically difficult to locate plots, continue numbering plots in sequence at the other side of the body of water, not numbering any plots that would have landed in the water. The plot immediately on the other side of the water should be randomly placed within distance chosen for the distance between plots. Subsequent plots are systematically placed at the previously determined distance.
- Plot location and distance between plots should be carefully noted. UTM coordinates of every station location should be recorded using a GPS.
- As soon as GPS coordinates are taken, a GIS map should be plotted with the station locations and verified for accuracy.

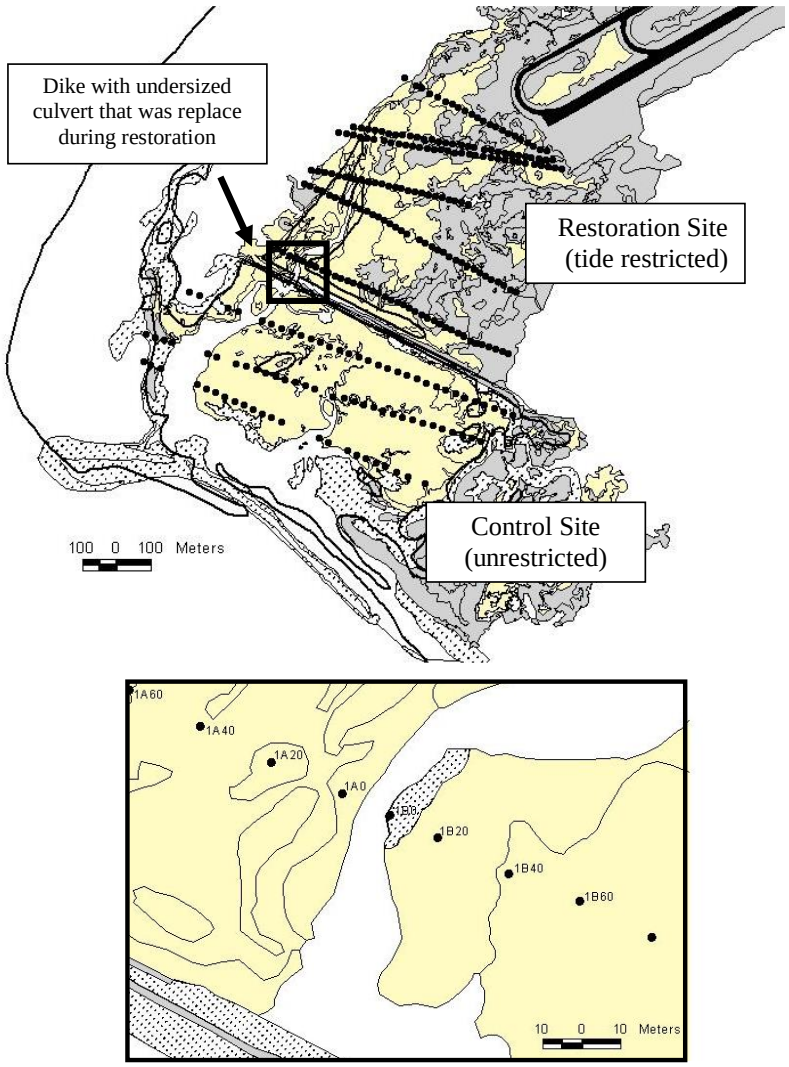


Figure 2-1. Map of Hatches Harbor Marsh, CACO, showing an example of transect and vegetation plot placement within a marsh. Note that at this site 2 areas were monitored, the northern portion of the marsh was undergoing restoration while the southern portion of the marsh served as a control site. Inset shows an example of numbering system for transects that cross tidal creeks.

3 SOP 3: Field Crew and Training Procedures

3.1 Number of Staff

- One supervisor and at least 2 field technicians are suggested to efficiently and accurately collect vegetation monitoring data.
- A minimum of 2 people are necessary to physically sample vegetation (for efficiency and safety in the field). A group of 4 people (2 teams of 2) dedicated to vegetation sampling were used in the initial protocol testing phase.
    - Point Intercept Method: One person conducts the point intercept method while the second person records the data.
    - Visual Cover Estimate Method: Two people are required to come to a consensus on the visual cover estimate category.
- It could take 1 team of 2 people 1-3 days to sample one marsh depending on the complexity of the vegetation community, logistics of accessing the marsh, and geography of study area.
- Individuals should be physically fit and be able to work long hours in the field. Conditions in the field can be harsh so it is imperative that individuals conducting the sampling are able to tolerate typical summer conditions on a salt marsh (*e.g.*, extreme heat, mosquitoes, physical labor, extensive walking in hip boots).

3.2 Training Procedures

- It is ideal for new staff to be trained by personnel who have previously sampled vegetation using these protocols. Training should take place prior to the sampling season (*i.e.*, 1 to 2 weeks before the first scheduled sampling).
- A trial sampling trip should be conducted so staff can practice the point intercept and visual cover estimation methods and learn to identify vegetation in the field.
- Staff should know how to use a GPS unit (see SOP 5 – Using a GPS).
- Staff should be able to identify common salt marsh vegetation. They should be familiar with plant anatomy, terminology used in field guides, and common field identification characteristics of vegetation. This can be learned on the job prior to sampling through training by an expert in vegetation identification.
- It is strongly urged that staff involve experts from local Universities or other agencies to assist with vegetation identification.
- If voucher or herbarium specimens are available from previous sampling, they should be studied by new staff.

3.3 Staff Qualifications

- A background in the sciences is preferred but not necessary.
- Familiarity with vegetation is preferred, but not necessary.
- Individuals should be physically fit, be able to work long hours in field conditions, be able to meet the travel and sampling scheduling constraints, and able to carry the necessary equipment.

4 SOP 4: Field Season Preparation (Scheduling and Equipment Preparation)

4.1 Establishing the Sampling Schedule

- Vegetation should be sampled once per year, at the end of the growing season (July through early September) when plant identification is easier.
- All marsh study areas should be sampled within the same time frame (within 1-2 weeks of each other) and occur when the marsh surface is not flooded so that tidal waters do not conceal vegetation.
- Sampling vegetation at parks in the northeast (e.g. BOHA, CACO, FIIS, SAIR, SAHI, GATE) should be conducted (preferably) in August or September when plants are fully grown, but before they have senesced for the winter.
- Parks in the mid-Atlantic states (e.g. ASIS, COLO, GEWA) can be sampled earlier (July through Septmeber) as plants will be mature earlier.
- Tide charts should be checked for each individual park and each study area should be visited prior to sampling at an appropriate tide (i.e. low or ebbing tide) to verify that that the marsh surface has drained of water.
- Sampling vegetation may have to re-scheduled if a major rain event or storm (hurricane) causes unexpected flooding of the marsh surface during the scheduled sampling period.

4.2 Supplies and Equipment

The following supplies are required in the field to sample vegetation:

4.2.1 Materials for Marking Station Locations

- GPS unit or map of study area to locate beginning of transects
- Oak stakes or flags to mark vegetation plots
- Mallet to pound stakes into ground
- Black permanent markers to mark transect and plot number on stakes
- Compass
- Meter tape (preferably 100m long)
- Random number table
- Aerial photos of study sites
- Draft map of study site showing boundaries of study areas and approximate location of transects

4.2.2 Materials for Point Intercept Method

- Meter stick
- 5-1m lengths of thin diameter (3-5mm) doweling.
- Colored electrical tape (to mark increments on dowels)
- Fluorescent orange or red spray paint (to paint dowels)
- Bayonet or thin rod for the point intercept method (less than 3mm diameter, approximately 60cm long).

Dowels should be painted, then marked with 10 evenly spaced (11.1 cm apart) increments. The first and last increments should correspond with each end of the dowel. Colored electrical tape can be used to mark increments.

The 5 dowels used to form the $1m^2$ plot are placed perpendicular to the meter stick at 0, 25, 50, 75, and 100cm - these increments on the dowels make up the 50 point grid of the point intercept method. It is helpful if the dowels are painted a bright color (e.g. fluorescent orange) and the increments are marked in a contrasting color (*e.g.*, yellow or white electrical tape) as this makes the dowels and increments on the dowels stand out in dense vegetation. It may also help to label the points on each dowel 1 to 10 in order to keep track of the points during sampling.

4.2.3 Materials for Visual Cover Estimate Method

- 4-1m lengths of thin diameter (3-5mm) doweling.
- Fluorescent orange or red spray paint (to paint dowels)

The 4 dowels are used to form the $1m^2$ plot within which percent cover of vegetation is estimated. It is helpful if the dowels are painted a bright color (*e.g.*, fluorescent orange) as this makes the dowels stand out in dense vegetation.

4.2.4 Personal Comfort and Safety Equipment in the Field

- Drinking water
- Hat
- Sunscreen
- Sunglasses
- Bug repellent and/or mosquito head netting
- Hip boots
- Snacks or lunch if sampling is for entire day
- Cellular phone or 2-way radio

We suggest that field staff inform either the supervisor or someone on the Park staff of where they will be sampling, what they will be doing, and an anticipated time of completion, so that in the case of an emergency the appropriate authorities can be informed of the location of the sampling crew.

4.3 Manuals and Identification Keys

We have found the following identification guides to be quite useful in the assisting with vegetation identification. This is not an exhaustive list and staff are urged to draw upon local experts to assist with identification if necessary. If a plant cannot be identified in the field, collect a specimen from OUTSIDE the vegetation plot, place in a clear labeled plastic bag with plot number for later identification. It is necessary to press specimens using a plant press if they are to be kept as voucher specimens.

General Vegetation

Gleason, H. A. and A. Cronquist. 1991. *Manual of Vascular Plants of Northeastern United States and Adjacent Canada* 2nd ed.The New York Botanical Garden, Bronx, NY. ISBN# 0-89327-365-1.

Holmgren, N. H. 1998. *Illustrated Companion to Gleason and Cronquist's Manual: Illustrations of the Vascular Plants of Northeastern United States and Adjacent Canada*. The New York Botanical Garden, Bronx, NY. ISBN# 0-89327-399-6.

Newcomb, Lawrence. 1977. *Newcomb's Wildflower Guide.* Little, Brown and Company, Boston, MA.

Regional Vegetation

Gould, L. L., R. W. Enser, R. E. Champlin, and I. H. Stuckey. 1998. *Vascular Flora of Rhode Island. A list of native and naturalized plants* Vol. 1. Rhode Island Natural History Society, Kingston, RI, The Biota of Rhode Island, ISBN# 1-887771-01-8.

Haines, A. and T. F. Vining. 1998. *Flora of Maine a Manual for Identification of Native and Naturalized Vascular Plants of Maine.* V. F. Thomas Co., Bar Harbor, ME. ISBN# 01-9664874-0-0.

McDonnell, M. J. 1979. *The Flora of Plum Island Essex County, Massachusetts.* New Hampshire Agricultural Experiment Station, University of New Hampshire, Durham, NH, Station Bulletin 513.

Niering, W. A. and R. S. Warren. 1980. *Salt Marsh Plants of Connecticut.* The Connecticut Arboretum, Connecticut College, New London, CT, Bulletin No. 25.

Phillips, C. E. 1978. *Wildflowers of Delaware and the Eastern Shore.* Delaware Nature Education Society, Hockessin, DE.

Silberhorn, G. M. 1982. *Common Plants of the Mid-Atlantic Coast - A Field Guide.* The Johns Hopkins University Press, Baltimore, MD. ISBN# 0-8018-2725-6.

Tiner, R. W. Jr. 1987. *A Field Guide to Coastal Wetland Plants of the Northeastern United States*. The University of Massachusetts Press, Amherst, MA. ISBN# 0-87023-537-0.

Useful Websites:

USDA Plants Database: http://plants.usda.gov/

ITIS (Integrated Taxonomic Information System) database: http://www.itis.usda.gov/

5 SOP 5: Using a GPS (Placeholder)

6 SOP 6: Sampling Salt Marsh Vegetation

Two methods, the point intercept and visual cover estimate, are presented for estimating vegetation cover. Point intercept is the preferred method as it is more quantitative and repeatable among different samplers. However, in tall vegetation canopies (>2m), the point intercept method is difficult to use and the visual cover estimate method can be used in these situations.

6.1 Point Intercept Method

The point intercept method collects data at 50 points systematically located through out a $1m^2$ plot. This method is quantitative and repeatable with little variation among different samplers.

- Locate the permanent stake marking the vegetation plot.
- In order to sample vegetation that has not been trampled during the establishment of transects, offset the $1m^2$ plot 1m from the stake (Fig. 6-1). Facing the direction of the transect (from the first plot towards the remaining plots of the transect) set the plot 1m to the right of the stake and orient the plot towards the direction of the transect (Fig. 6-1). Be sure to maintain the same offset for all plots and record a detailed description of the offset.
- Document the orientation of the plot relative to the plot stake with a schematic diagram such as that shown in Fig. 6-1.
- Place the meter stick on the marsh surface in the proper orientation, and place the 5 dowels perpendicular to the meter stick at 0, 25, 50, 75, and 100cm intervals along the meter stick. Each dowel is 1m in length and has a total of 10 marks, each spaced 11.1cm apart (Fig. 6-2). Thus, the $1m^2$ plot is divided into a grid of 50 evenly spaced points. In dense vegetation it may be necessary to weave the dowels through the vegetation.
- List all species that are present within the sample plot on the data sheet for that plot (refer to SOP 7 for data sheets).
- If a species cannot be identified in the field, collect a specimen from OUTSIDE the vegetation plot and place it in a plastic bag that is clearly labeled with the plot number and unique plant identification number (*e.g.*, "Unknown # 1", "Unknown #2")
    - All unidentified plants should be recorded on the data sheet as Unknown # 1", "Unknown #2", *etc*. with their cover class estimate and placed in a plastic bag clearly labeled with the plot number and voucher specimen number (*e.g.*, "Unknown # 1", "Unknown #2", *etc*.).
    - Once unidentified plants are identified, the correct species identification should be indicated on the field data sheet with the date and the initials of the person that verified the identification.
- Hold the thin rod vertical to the first sampling point and lower the rod through the vegetation canopy to the sample point on the ground.
- All species that touch the rod are recorded as a "hit" on the data sheet for that point. Hits are indicated by making an "X" in the box for the appropriate point for that species.

- Categories other than plant species, such as "water", "bare ground", "standing dead", "wrack or litter," and others are also recorded if they are "hit" by the rod. Table 6-1 provides definitions of cover type categories that should used when sampling salt marsh vegetation.
- More than one cover type category can touch the rod at each point, and thus multiple cover types for each sample point should be recorded if appropriate. However, it is not necessary to count the number of hits for each individual species. For example, if *S. alterniflora* touches the rod in 3 places, it is recorded as one hit of *S. alterniflora* for that point. At least one cover type should be recorded for each point (*i.e.*, if there is no vegetation, "bare ground" or "water" may be the appropriate cover type).
- After the first point is completed, the process is repeated for all remaining points on the sampling plot until all 50 points have been sampled.
- Tally the total number of hits per species or cover type for each plot on the data sheet. This can be done after returning to the laboratory.

6.2 Visual Cover Estimate Method

The visual cover estimate is an estimate of the percent cover of vegetation cover classes within a $1m^2$ vegetation plot. This method requires training to familiarize the sampler with estimating percent cover by visualization. It is recommended that the SAME team of samplers estimate all plots to reduce error among samplers. This method is not as repeatable as the point-intercept method and should only be used when the point intercept method cannot be used (as in the case of tall vegetation canopy in excess of 2m high).

- Locate the permanent stake marking the vegetation plot.
- In order to sample vegetation that has not been trampled during the establishment of transects, offset the plot 1m from the stake (Fig. 6-1). Facing the direction of the transect (from the first plot towards the remaining plots of the transect) set the plot 1m to the right of the stake and orient the plot towards the direction of the transect (Fig. 6-1). Be sure to maintain the same offset for all plots and record a detailed description of the offset.
- Document the orientation of the plot relative to the plot stake with a schematic diagram such as that shown in Fig. 6-1.
- The 4 dowels are used to form a $1m^2$ plot.
- List all species that are present within the sample plot on the data sheet for that plot (refer to SOP 6.4 for data sheets).
- If a species cannot be identified in the field, collect a specimen from OUTSIDE the vegetation plot and place it in a plastic bag that is clearly labeled with the plot number and unique plant identification number (*e.g.*, "Unknown # 1", "Unknown #2")
    - All unidentified plants should be recorded on the data sheet as Unknown # 1", "Unknown #2", *etc*. with their cover class estimate and placed in a plastic bag clearly labeled with the plot number and voucher specimen number (*e.g.*, "Unknown # 1", "Unknown #2", *etc*.).

    - Once unidentified plants are identified, the correct species identification should be indicated on the field data sheet with the date and the initials of the person that verified the identification.
- The two samplers stand over the plot and silently estimate the percent cover category (see below) of each individual species or cover types.
- Once each sampler has come to an estimate, they speak the estimate out loud. If the estimates are the same then the visual cover class is written on the datasheet. If the estimates are different then the samplers re-evaluate the cover class estimate until they agree on one cover class category for the specie of cover class.
- The method is repeated for all species and cover classes within the plot.

6.2.1 Visual Cover Estimate Categories

The following cover class categories are used to determine percent cover for individual cover types within the vegetation plot. Fig. 6-3 will help aid in the visualization of these cover classes. It is EXTREMELY IMPORTANT that samplers using the visual estimate cover method are able to arrive at the SAME cover class category repeatedly. This is usually only accomplished after samplers have extensive experience with this method.

1: Less than 1% (usually only 1 specimen in plot)
2: 1% to 5% cover
3: 6% to 10% cover
4: 11% to 25% cover
5: 26% to 50% cover
6: 51% to 75% cover
7: 76% to 100% cover

6.3 Height of Species of Interest

Height of species of interest such as the common red (*Phragmites australis*) should be measured within vegetation plots where it occurs. For example, *Phragmites* height will indicate the vigor of the species and its response to changes in hydrology.

- Height of Phragmites should only be done after the plants have produced a seed head.
- Height is measured to the tallest portion of the plant, such as the leaves (when stretched out over head) or the top of the seed head.
- If there are 20 or fewer stems, measure all stems in the plot
- If there are more than 20 stems in the plot, divide the 1m plot into quarters and randomly select one quarter section of the plot. Measure all stems within the randomly selected quarter.

6.4 Vegetation Data Sheets

Examples of Point Intercept, Visual Cover Estimate, and *Phragmites* height data sheets are shown in Figs. 6-4, 6-5, and 6-6, respectively.

- All information should be filled out on the data sheets in the field.
- If species are identified back in the lab, the person verifying the identification should date and initial the identification on the data sheet.
- Any changes or edits to information on the field data sheet must include the date and initials of the person making the change.

- Upon return from sampling, all data sheets should be checked to make sure they include all information. If any information is missing every attempt should be made to complete the missing information. The person completing the missing information must initial and date the change and/or addition.

Table 6-1. Cover type categories to be included in the point-intercept salt marsh vegetation program.

Live vascular plants (herbaceous and shrubs) identified by species

Standing dead vascular plants identified by species (*e.g., S. alterniflora* dead). This category only includes standing dead (attached) plants that are from a previous year's growth. There may be some dead leaves from this year's growth (*e.g.,* the ends of leaves or leaves that are being replaced by new growth, *etc.*). If you are sure these dead leaves are from the current growing season, then record as live. Dead plant material from a previous growing season is recorded as "liter" (see below).

Macroalgae identified by species. This category generally includes the rockweeds (*e.g.*, *Fucus*, *Ascophyllum*). Microalgae (*e.g.*, diatom mats) and fine filamentous algae are not included in this category.

Bare. Includes mud, sand, microalgae cover, *etc*. These are areas that are not flooded with water and are devoid of standing live, standing dead, or macroalgae. There can be a thin film of surface water within the bare category.

Water. Permanent standing water is identified in plots that are partly within a creek, ditch, marsh pool, or flooded panne.

Wrack/Litter. Wrack is material that has floated into the plot. This is generally dead (not attached) plant material, but could also be trash. Litter is dead plant material that is highly decomposed, if from a previous years growing season, and may or may not be attached. It is not identified to species, as is standing dead (see above).

Trash. Items such as logs, old piers, tires, etc.

Rock. Boulders or rocks can be found on the surface of northern New England marshes.

NOTES:

- If an intercept point has standing water that is covering a bare mud bottom, this point should be recorded as standing water. It is assumed that the bottom is bare and there is no need to record this.
- If macroalgae or submerged aquatic vegetation are hit at the intercept point in a standing water habitat, then both the plant and water should be recorded.
- If a plot is at the edge of a marsh pool (water), *Spartina* overhangs the water, and the intercept point hits the *Spartina* and water, then both *Spartina* and water should be recorded.

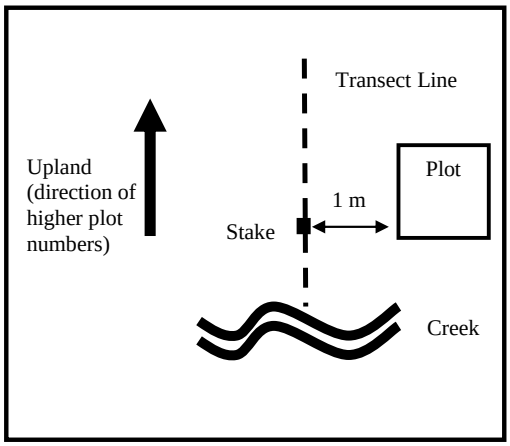
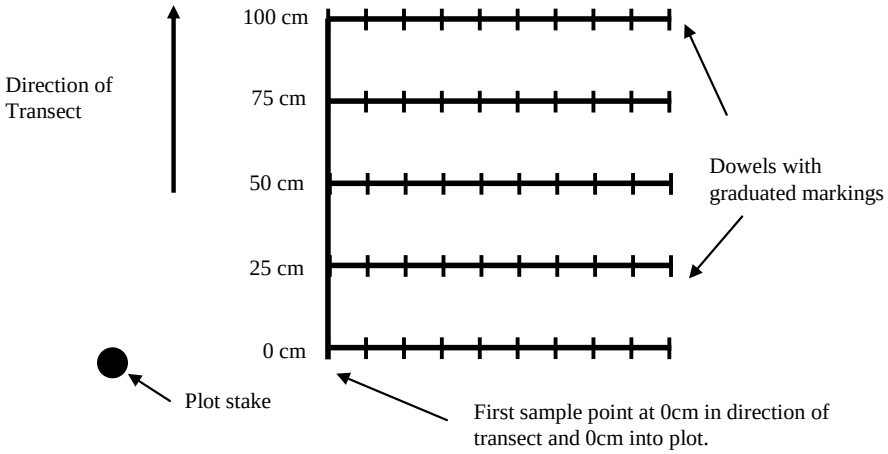


Figure 6-1. A schematic of the orientation of the vegetation plot relative to marker stake.



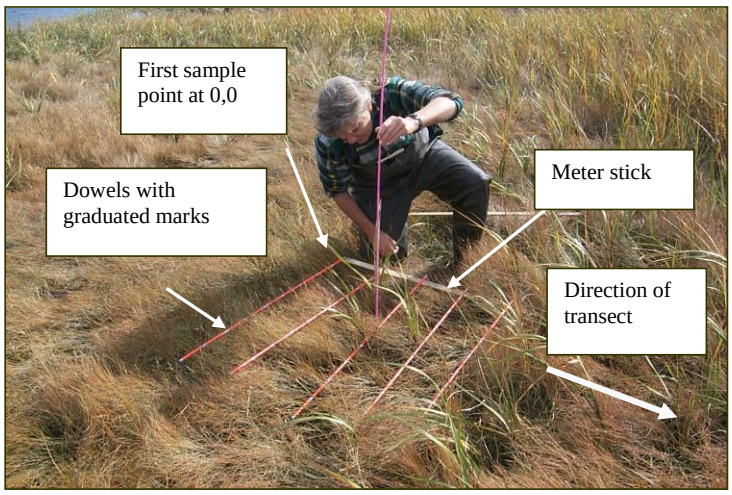
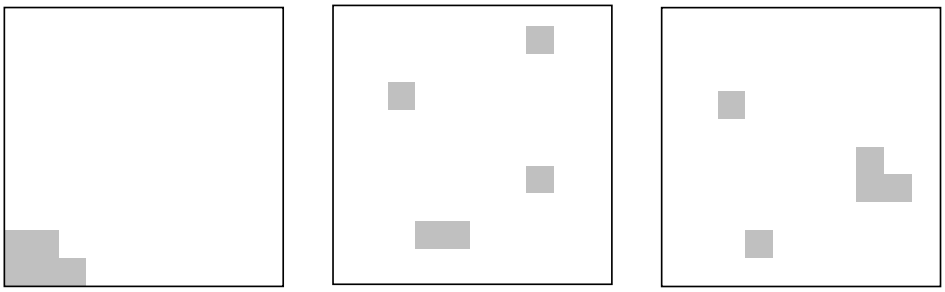
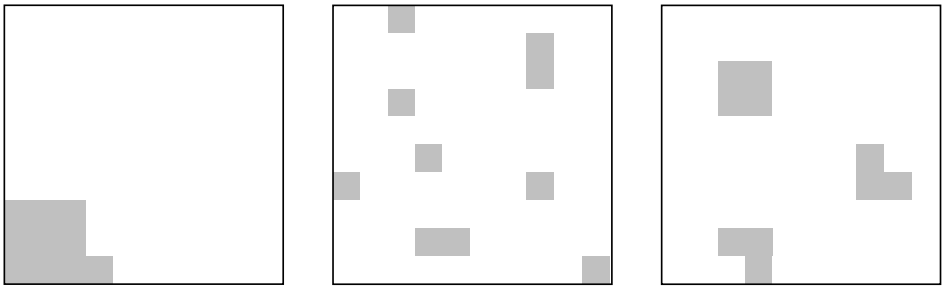


Figure 6-2. Schematic and photo of the sample plot and arrangement of dowels used in the point intercept method

1% to 5%: These are all 5% cover



6% to 10%: These are all 10% cover



11% to 25%: These are all 25% cover

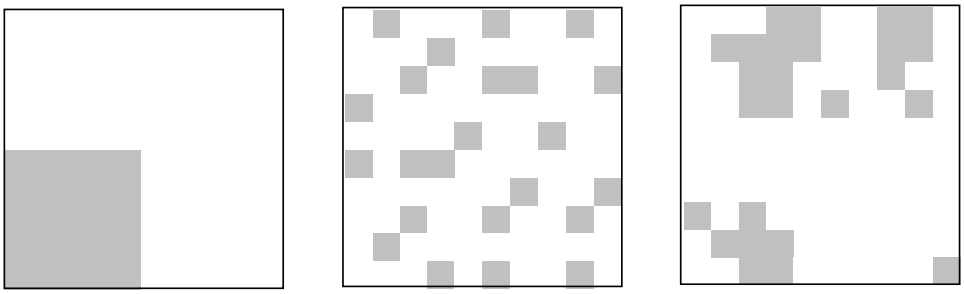


Figure 6-3. Schematic diagrams of the different visual cover class categories.

VEGETATION DATA SHEET (1m^2 point intercept method)

Site _____ Field Crew _____ Date _____ Time_____

Plot ID _____ Coord N: _____`_____Coord W:_____

Point-- record species, first row is for points 1-25, second row is for points 26-50.

SPECIES	1 26	2 27	3 28	4 29	5 30	6 31	7 32	8 33	9 34	10 35	11 36	12 37	13 38	14 39	15 40	16 41	17 42	18 43	19 44	20 45	21 46	22 47	23 48	24 49	25 50	Total Tally
1.																										
2																										
3																										
4																										
5																										
6																										

Figure 6-4. Point intercept data sheet.

SITE_____ **DATE**_____ **TIME**_____

PLOT ID _____ **TEAM**_____

GPS Coord. N:_____ **E:**_____

Comments_____

Braun-Blanquet Cover Classes:

1: <1%	4: 10% to 25%	7: 76% to 100%
2: 1% to 5%	5: 26% to 50%	
3: 6% to 10%	6: 51% to 75%	

Species	**Cover Class**
#1 _____	_____
#2 _____	_____
#3 _____	_____
#4 _____	_____
#5 _____	_____
#6 _____	_____
#7 _____	_____
#8 _____	_____
#9 _____	_____
#10 _____	_____

Figure 6-5. Data sheet for visual cover estimate of vegetation.

Plant Height Data Sheet

Site_____ Date_____ Time _____

Species _____ Plot ID _____Sampling Team_____

GPS Coord. N:_____ E:_____

Heights (mm) of stems plot

# 1-15	**#16-30**	**#31-45**	**#46-60**
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

Figure 6-6. Data sheet for recording height of species of interest such as *Phragmites australis*.

7 SOP 7: Collecting Ancillary Data (Ground Water Table and Soil Salinity)

7.1 Groundwater Table Level

Groundwater table wells are located adjacent to vegetation plots. Groundwater table wells are installed adjacent to permanent vegetation plots (Fig. 7-1). The proximity to vegetation sampling stations allows for easier sampling provides information on groundwater table level in the same area where vegetation data are collected.

7.1.1 Materials for Groundwater Wells

- 1.5 inch (4 cm) interior diameter, schedule 40, PVC Tubes (comes in 10ft lengths and can be purchased at hardware stores)
- PVC caps to fit the tubes. Two caps (rounded preferably) are required for each well
- ¼ inch drill bit and drill
- Meter sticks
- Black permanent markers to mark well number on caps
- Mallets to pound wells into the ground
- Blocks of wood to place on well top when wells are pounded (prevents PVC from cracking)

7.1.2 Groundwater Well Fabrication

- Cut PVC into 70 cm lengths (4 wells per 10 ft of tube), 10 cm will be aboveground, 60cm will be belowground.
- Drill ¼ inch holes in the belowground section of the well (along the 10–60cm length of the well). Drill enough holes to allow water to percolate into the well (*e.g.*, 4 rows of 5 to 10 holes). The top of the well is the 0-10cm section that has no drill holes; the bottom of the well is the section with the drill holes. To prevent surface water from entering the well the top 0-10cm section of the well is left intact.
- Place a cap on the bottom of each well. Well bottoms should fit snugly, but do not need to be glued.
- Draw a line 10cm from the top of the well. In the field, this line will serve as a guide for how deep the well should be installed. The well will be driven into the marsh up to this line.
- The remaining caps are for the top of the wells.
- Drill a ¼ inch hole in the center of the remaining top well caps. The cap is used to prevent rainwater from entering the well. A hole is drilled in the center of the top cap for venting.
- Well top caps are installed in the field.

7.1.3 Installing Groundwater Table Wells

- Locate vegetation plot.
- Place the groundwater well 1m away from the plot stake in the direction of the transect and pound the well into the marsh (Fig. 7-2).

- Pound well until only 10cm of well is above ground and all drill holes are below the marsh surface. Use 10cm mark on the well as a guide.
- Label top cap (cap with center drill hole) with the vegetation plot identification number. The well number will be the same as the adjacent vegetation plot number.
- Place top cap loosely on well top. Do not jam the cap onto the well top. These caps must be removed to measure the water table level.

7.1.4 Timing and Frequency of Groundwater Table Sampling

- Groundwater table level should be measured at the same time as soil water salinity
- Groundwater table level should be measured within 2 hours of low tide.
- Sampling should occur when the marsh surface has drained of water.
- Sampling should occur throughout the growing season (*e.g.*, May through October) at 7 to 10 day intervals.
- At a minimum there should be at least 3 sampling events per month throughout the growing season.

7.1.5 Sampling Groundwater Table Level

- Record all information on Water Table Level and Soil Salinity Monitoring data sheet (Figure 7-3).
- Record station number. Station number is the same as the vegetation plot number.
- Remove well cap.
- Insert the meter stick into well (0mm end first) until the meter stick barely touches the water surface. By peering into the well as the meter stick is lowered you will be able to see the surface tension of the water break as the meter stick reaches the water surface.
- Record the measurement from the top of the water to the top of the well (Measurement A in Figs. 7-2 and 7-3).
- Record the height of the well from the marsh surface (Measurement B in Figs. 7-2 and 7-3). This measurement is important because the well could move from freezing/thawing, trampling, vandalism, *etc*.
- Subtract the height of the well from the marsh surface from the total distance of the top of the well to the water level. This will give the distance of the water level below the marsh surface (it will be a negative number if water is below the marsh surface). This calculation will be done back in the office and should not be done in the field. The above two numbers are all that is required to be recorded in the field.
- If the well is dry (no water in the well at all), record “dry” on the data sheet.
- If the marsh surface is flooded, measure the depth of the water from the marsh surface to the water surface. Write “surface” on the data sheet next to this measurement.
- Replace the top cap. Be sure not to jam the cap onto the well top.

- Refresh the well label with permanent marker to ensure that it will be visible in the next sample season.

7.1.6 Groundwater Table Data Sheet

- The data sheet for recording groundwater measurements is shown in Fig. 7-3

7.1.7 Calculating Groundwater Table Level

- Groundwater table level is calculated by subtracting the height of the top of the well to the marsh surface (B in Fig. 7-2) from the distance of the top of the well to the water in the well (A in Fig. 7-2).
- If the groundwater level is below the surface of the marsh, the resulting depth will be negative.
- If there is water on the surface of marsh, the depth will be positive representing the depth of the water on the marsh surface.
- If the well is dry, a distance of -45cm (minus 45cm), the length of the groundwater well, should be recorded in the database. This represents the maximum distance below the marsh surface that water can be detected.
- This calculation should be done back in the office. The above two numbers are all that is required to be recorded in the field.

7.2 Soil Water Salinity

Soil water salinity is an important factor controlling the patterns of salt marsh vegetation. A soil probe is recommended for collecting soil water. Soil water salinity is taken adjacent to groundwater wells (refer to Fig. 7-1). The proximity to vegetation sampling stations allows for easier sampling as well as provides information on soil water salinity in the same area where vegetation data are collected.

7.2.1 Materials for Soil Salinity

- Soil probe, constructed of stainless steel tubing (such as gas chromatograph tubing) 0.065 in inner diameter, 0.085in outer diameter, cut to 70cm length, with one end crimped and slotted to allow entry of soil water (Fig. 7-4)
- 10-15cc plastic syringe, or larger volume syringe up to 60cc
- 5cm length of plastic tubing to attach the soil probe to the syringe
- Hand-held refractometer
- Filter paper (cut-up coffee filters can be used)
- Plastic squeeze bottle with freshwater to rinse and calibrate refractometer

7.2.2 Soil Probe Fabrication

- Make 3 – 4 slits approximately 5mm apart and 2.5cm from one end of the metal tubing. The slits can be made with a roto-tool or a fine blade hacksaw. The slits should extend into the inner cavity of the tube and allow water to be drawn up into the tube (Fig. 7-4).
- Close the end of the metal tube (nearest to the slits) by crimping with pliers or a vice.
- Attach a short length of plastic tubing to the uncrimped end of the metal tubing.

- Attach the syringe to the other end of the plastic tubing.
- Make sure that water can be drawn up into the tubing by pulling the plunger on the syringe.
- Mark increments of 15cm, 30cm, and 45cm on the metal tube with tape so that depth of the soil salinity sample can easily be determined.

7.2.3 Temporal Frequency of Soil Salinity Sampling

- Soil salinity should be measured at the same time as groundwater table level.
- Soil salinity should be measured within 2 hours of low tide.
- Sampling should occur when the marsh surface has drained of water.
- Sampling should occur throughout the growing season (*e.g.*, May through October) at 7 to 10 day intervals.
- At a minimum there should be at least 3 sampling events per month per the growing season.

7.2.4 Sampling Soil Water Salinity

- Record all information on the Water Table Level and Soil Salinity Monitoring data sheet (Figure 7-3)
- Sampling should coincide with groundwater well sampling and should always be measured within 2hrs of low tide.
- Calibrate (zero) hand-held salinity refractometer with fresh water (tapwater is okay) before EACH field day.
- Record station number. Station number is the same as the vegetation plot number.
- At a location near the groundwater well, insert the soil salinity probe (crimped end downward) 15cm into the sediment (tape can be used to mark 15cm). Carefully withdraw the plunger on the plastic syringe to draw soil water into the syringe.
- If no water is drawn up at 15cm, then insert the probe deeper (30cm, then 45cm) until soil water is drawn up into the syringe. Record the depth that soil water was collected. Record dry if no soil water was collected at 45cm.
- Once several milliliters of water have been withdrawn into the syringe, detach it from the probe.
- Place a piece of filter paper over the nozzle of the syringe. Depress the syringe plunger and let the water pass through the filter paper and onto the glass plate of the refractometer.
- Read and record the soil water salinity (ppt) on the data sheet (Fig. 7-3).
- Clean-up. Discard (never re-use) the filter paper. Using water from the groundwater well or a nearby creek, rinse silt and sediment from the probe by drawing up water into the syringe. Discard all the water in the syringe and probe before sampling the next station. Rinse refractometer with freshwater.
- Check the probe frequently to make sure it is not clogged with fine sediment. The finer the sediment (*e.g.*, mud, clay) the more likely the probe is to get clogged.
- It is possible to get hypersaline readings (above 30 ppt) during hot summer days, however be sure that the refractometer is calibrated prior to each sampling day.

7.2.5 Soil Salinity Data Sheet

- The data sheet for recording soil salinity measurements is shown in Fig. 7-3.

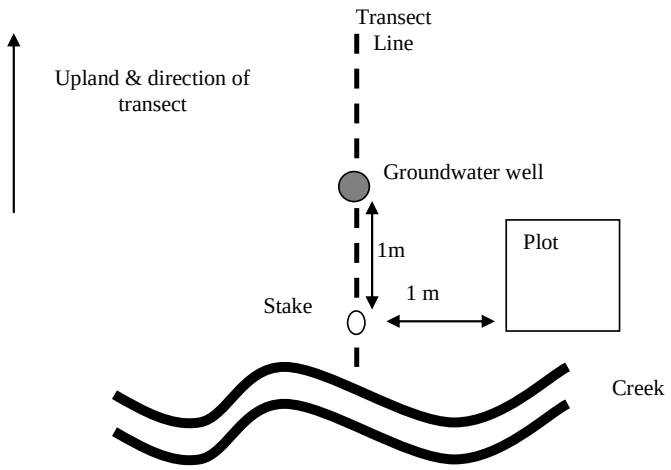


Figure 7-1. Schematic showing the location of groundwater well relative to stake and vegetation plot.

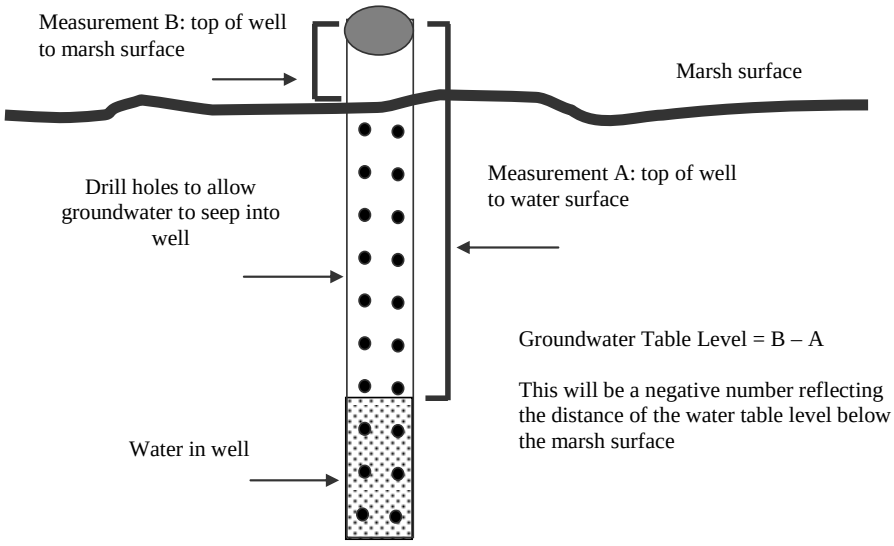


Figure 7-2. Schematic of groundwater well in place in the marsh and guide to measurements taken in the field.

Water Table Level & Soil Salinity Monitoring

SITE _____ DATE _____

Data Collector(s) _____

Note: *If water is below marsh surface indicate water table level with a negative sign in "Depth Column". If water is on the marsh surface, write "surface" in Column A, measure water depth and record depth with a positive sign in "Depth" column. If water is below marsh surface than water table depth will be negative. If water is on marsh surface than depth will be positive.*

Plot No.	Time	A. Top of Well to Water (cm)	B. Top of Well to Marsh (cm)	Depth to Water Table (B-A)[1]	Salinity (ppt)	Depth if other than 15 cm

Figure 7-3. Data sheet for groundwater table and soil salinity.

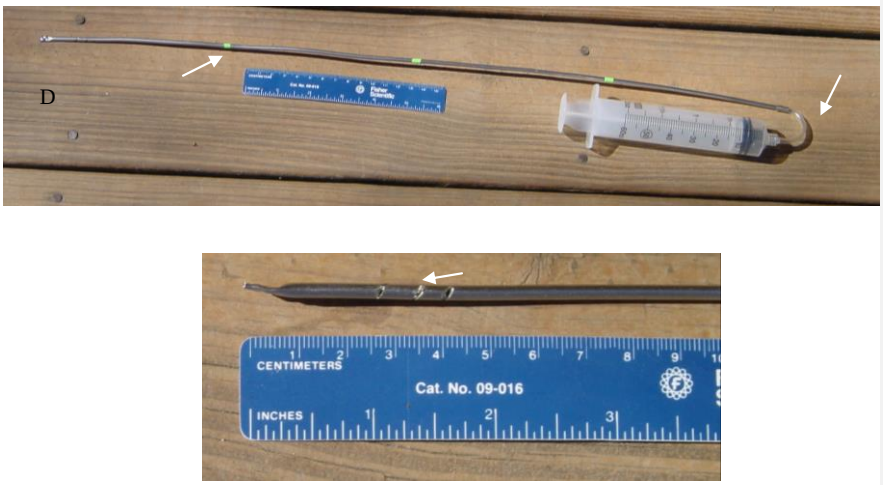


Figure 7-4. Photograph of a soil probe used to sample soil water salinity

8 SOP 8: - Data Management (Placeholder for Network)

VEGETATION MONITORING IN SALT MARSHES OF THE NORTH COASTAL AND BARRIER NETWORK

STANDARD OPERATING PROCEDURE (SOP) # 9

DATA ANALYSIS

VERSION 1.00 (OCTOBER 14, 2004)

Revision History Log for SOP #9:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
none	10/14/04	Sue Huse	Original SOP	-	1.0

This Standard Operating Procedure (SOP) provides detailed instructions for analyzing Salt Marsh Monitoring data collected by the National Park Service Northeast Coastal and Barrier Network (NCBN). Two protocols are being used by the Network, one to monitor nekton and one to monitor salt marsh vegetation. This SOP describes how to create and report data summaries annually, and how to prepare data optional long-term trends and multivariate analyses by researchers as needed for the vegetation monitoring.

Contents:

Formatted: Font: (Default) Times New Roman, 12 pt, Not Bold

Formatted: Font: (Default) Times New Roman, 12 pt, Not Bold

Formatted: Font: 12 pt

Formatted: Normal

1. Introduction

This Standard Operating Procedure (SOP) provides detailed instructions for analyzing Salt Marsh Monitoring data collected by the National Park Service Northeast Coastal and Barrier Network (NCBN). Two protocols are being used by the Network, one to monitor nekton and one to monitor salt marsh vegetation. This SOP describes how to create and report data summaries annually, and how to prepare data optional long-term trends and multivariate analyses by researchers as needed for the vegetation monitoring.

Formatted: Font: 14 pt, Italic

Formatted: Bullets and Numbering

2. Reporting Requirements

2.1 8.1 Annual Reporting

On an annual basis the following analyses will be conducted for vegetation monitoring included in the NCBN Salt Marsh Monitoring Annual Report. The data analyses will include basic species occurrences and metrics. All data will be summarized by marsh within each park for the sampling year.

Species occurrence and species percent cover will be included in the NCBN Salt Marsh Monitoring Annual Report. This does not restrict the inclusion of additional relevant analyses. Instructions for calculating and reporting these analyses directly from the database are included in this SOP.

The Salt Marsh Monitoring Database includes tools that automate the reporting of each annual summary table.

8.1.1 Automated Reporting

- SThese are available by select ing *Analysis and Export* from the *Main Menu* of the database.
- Sand then select ing *Summary Reports*.
- Select summary of interest from the list (Fig. 8-1)
- Click *Preview* to view the report or *Print* to print it.

8.1.2 Export Digital Version of Summary Data

- Select *Export Data to Excel* from the *Analysis and Export* menu
- Select the summary of interest from the list and click *Preview* to view the report or *Print* to print it.
- To export a digital version of these summary data for direct inclusion in a text document or for use in a spreadsheet or other program, select *Export Data to Excel* from the *Analysis and Export* menu. Select the summary table of interest (Fig. 8-2)and .
- Cclick *Preview* to view the table or *Export* to save it to an Excel formatted file.

Formatted: Font: (Default) Times New Roman, 12 pt, Not Bold, Not Italic, Underline

Formatted: Font: (Default) Times New Roman, 12 pt, Not Bold, Italic

Formatted: Heading 3

Formatted: Bullets and Numbering

Formatted: Bulleted + Level: 1 + Aligned at: 0.25" + Tab after: 0.5" + Indent at: 0.5", Tab stops: Not at 4.65"

Formatted: Font: (Default) Times New Roman, 12 pt, Not Bold, Italic

Formatted: Font: (Default) Times New Roman, 12 pt, Not Bold, No underline

Formatted: Heading 3, Tab stops: Not at 4.65"

Formatted: Normal, Bulleted + Level: 1 + Aligned at: 0.25" + Tab after: 0.5" + Indent at: 0.5", Tab stops: Not at 4.65"

Formatted: Font: 12 pt

Formatted: Font: 12 pt, Italic, Underline

Formatted: Bulleted + Level: 1 + Aligned at: 0.25" + Tab after: 0.5" + Indent at: 0.5"

Formatted: Bulleted + Level: 1 + Aligned at: 0.25" + Tab after: 0.5" + Indent at: 0.5"

Formatted: Bullets and Numbering

Formatted: Bulleted + Level: 1 + Aligned at: 0.25" + Tab after: 0.5" + Indent at: 0.5"

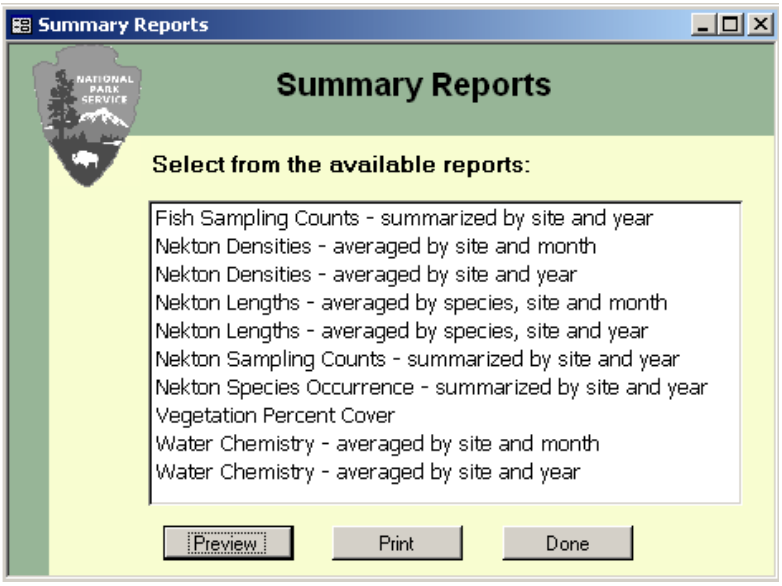


Figure 8-1. Summary Reports for printing.

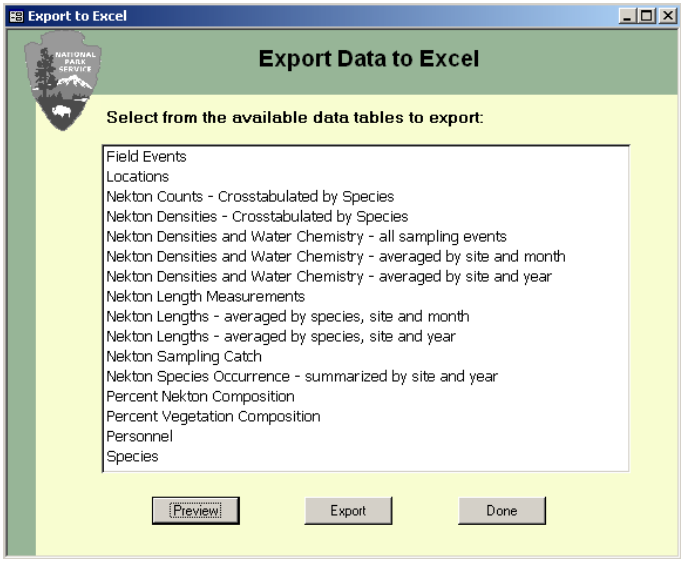
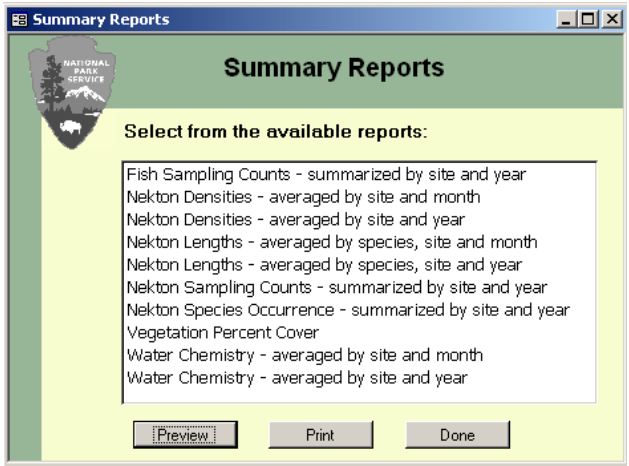


Figure 8-2. Table export to Excel file format



~~2.2~~8.2 Multiyear Change Analysis and Comparisons Across Sites

The Salt Marsh Monitoring protocol collects data that can be used to analyze the changes in salt marsh ecology over time, and between monitoring sites and across parks. The protocol includes monitoring each site every three years. The time lag between site visits precludes annual change analyses. Instead, the Principal Investigator and the Network Coordinator will determine how often change analyses should be conducted. The Principal Investigator and the Network Coordinator will also work with park staff to determine if other analyses are required, for which sites, and how often they should be performed. Instructions are included in the sections below for some intermittent analyses.

Formatted: Underline

Formatted: Font: (Default) Times New Roman, 12 pt, Not Bold, Not Italic, Underline

Formatted: Heading 2

Formatted: Bullets and Numbering

Formatted: Indent: Left: 0"

Formatted: Heading 2

Formatted: Bullets and Numbering

~~3. Annual Analyses of Vegetation Monitoring Data~~

~~3.1~~8.3 *Calculating and Reporting Percent Cover – Point Intercept Method*

- Since 50 points are using in the 1m^2 grid, percent cover from raw data sheets is calculated by dividing the total number of hits by 50 (*i.e.* 10 hits/50 possible hits = 20% cover)

~~3.1.1Annual Reporting of Percent Cover - Point Intercept Method~~

Percent Cover (Point Intercept Method) by Species and Site =

Σ (Percent cover of a species) ~~by~~ for all stations per site /

Σ (Total percent cover of all species) for all stations by site

The percent cover for a species across a marsh site equals the sum of percent cover for that species across all stations in the site, divided by the total percent cover of all species across all stations in the site. This is repeated for all species found at the site. Percent cover values for an individual sampling event at a station do not always sum to 100% with the salt marsh monitoring protocol. This is because more than one species can be present at one grid point – there can be both over and understory vegetation. ~~Percent cover values summed across a site, therefore, will also have values that may be greater than 100%.~~By dividing the individual species percent cover by the total percent cover of all species for the marsh, percent cover for all species for the marsh is standardized to sum to 100%

8.3.1 Automated Percent Cover Summaries

Formatted: Font: (Default) Times New Roman, 12 pt, Not Bold

Formatted: Heading 3, Bulleted + Level: 1 + Aligned at: 0.25" + Tab after: 0.5" + Indent at: 0.5"

Formatted: Font: 12 pt, Superscript

Formatted: Font: 12 pt, Italic

Formatted: Font: (Default) Times New Roman, 12 pt, Not Bold, Italic

Formatted: Heading 3, Indent: First line: 0", Tab stops: Not at 1.19"

Formatted: Indent: Left: 0", Tab stops: 0", Left + Not at 1.25"

Formatted: Font: (Default) Times New Roman, 12 pt, Not Bold, Italic

Formatted: Heading 3

Formatted: Bullets and Numbering

Formatted: Indent: Left: 0", Tab stops: 0", Left + Not at 1.25"

The Salt Marsh Monitoring database includes an automated routine for generating the percent cover summaries. The analysis output is available as either a report or an export table format (Fig. 8-3).

- To create a printable report, select *Analysis and Export* from the *Main Menu*.
- , Sthen select *Summary Reports*.
- From the list of available reports, highlight *Vegetation Cover, Point Intercept - averaged by site and year*.
- Click *Preview* to view the report or *Print* to print it.

8.3.2 *Export Digital Version of Summary Report*

- To export a digital version of this data for direct inclusion in a text document of for use in a spreadsheet or other program, select *Analysis and Export* from the *Main Menu*.
- , Sthen select *Export Data to Excel*.
- From the list of available reports, highlight *Vegetation Cover, Point Intercept - averaged by site and year, or Vegetation Cover, Point Intercept – all data*, depending on your needs.
- Click *Preview* to view the table or *Export* to save it to an Excel formatted file.

To create a report or export the data for only a subset of the data, you will need to edit the criteria in the base query: "qry_Analysis_SM_VegCoverPI". Follow the instructions in the section "Subsetting Query Data. *Be sure to go back to the base query and remove your changes before running any other analyses!*

Figure 8-3 Summary report for point intercept data (percent cover).

Formatted: Indent: Left: 0", Tab stops: 0", Left + Not at 1.25"

Formatted: Bulleted + Level: 1 + Aligned at: 0.25" + Tab after: 0.5" + Indent at: 0.5", Tab stops: 0", Left + Not at 1.25"

Formatted: Bullets and Numbering

Formatted: Indent: Left: 0", Tab stops: -0.13", Left + Not at 1.25"

Formatted: Font: (Default) Times New Roman, 12 pt, Italic

Formatted: Heading 3

Formatted: Bullets and Numbering

Formatted: Bulleted + Level: 1 + Aligned at: 0.25" + Tab after: 0.5" + Indent at: 0.5", Tab stops: -0.13", Left + Not at 1.25"

Formatted: Indent: Left: 0", Tab stops: 0", Left + Not at 1.25"

~~3.2~~8.4 Calculating and Reporting Percent Cover – Braun Blanquet Method

~~3.2.1~~*8.4.1 Annual Reporting of Percent Cover - Braun Blanquet Method*

The monitoring protocol specifies the use of the Braun-Blanquet method to estimate percent cover in areas where the vegetation height and density physically preclude the use of a point intercept method. With the Braun-Blanquet method a researcher assigns a value from 1 to 7 to score the percent cover for each species found. A value of 1 represents <1% cover by that species~~,~~ and a 7 represents 76% to 100% cover for that species. Because these scores are categorical percent cover classes rather than true percent covers, they do not lend themselves to mathematical averaging of percent cover. Braqun-Blanquet cover classes are averaged to obtain an average score for each plant species or cover type. These average will range from 0 to 7.

If an average ~~Braun-Blanquet score or~~ percent cover is necessary, the Braun-Blanquet scores can be converted to estimated percent cover using the ~~the standard method is to assign the~~ median value of percent cover for each ~~class~~ Braun_Blanquet score and use these values to calculate the average. For instance, for class 6, the range is 51-75% and the median value would be 63%. The averaging calculation uses 63% for scores of 6. In reporting site averages for Braun-Blanquet vegetation cover estimates, include both the average of the scores and the averages of the percent cover estimates.

The Salt Marsh Monitoring database includes an automated routine for generating the percent cover summaries for the Braun-Blanquet method. The analysis output is available as either a report or an export table format.

8.4.2 Automated Printable Report

- ~~To create a printable report,~~ Sselect *Analysis and Export* from the *Main Menu*
- ~~,~~ S~~then s~~elect *Summary Reports*.
- From the list of available reports, highlight *Vegetation Cover, Braun-Blanquet - averaged by site and year*.
- Click *Preview* to view the report or *Print* to print it.
-

8.4.3 Export a Digital Version of Data

Formatted: Font: (Default) Times New Roman, 12 pt, Not Bold, Not Italic, Underline

Formatted: Heading 2

Formatted: Bullets and Numbering

Formatted: Font: (Default) Times New Roman, 12 pt, Not Bold, Italic

Formatted: Heading 3, Indent: First line: 0", Tab stops: Not at 1.19"

Formatted: Indent: Left: 0", Tab stops: 0", Left + Not at 1.25"

Formatted: Bullets and Numbering

Formatted: Font: (Default) Times New Roman, 12 pt, Not Bold, Italic

Formatted: Heading 3, Tab stops: Not at 0"

Formatted: Heading 3, Tab stops: Not at 0"

Formatted: Font: (Default) Times New Roman, 12 pt, Not Bold, Italic

- ~~To export a digital version of this data for direct inclusion in a text document of for use in a spreadsheet or other program, S~~select *Analysis and Export* from the *Main Menu*.
- ~~, S~~then select *Export Data to Excel*.
- From the list of available reports, highlight *Vegetation Cover, Braun-Blanquet - averaged by site and year, or Vegetation Cover, Braun-Blanquet – all data*,

qry_Analysis_SM_VegCoverBBAvgs_SiteYear : Select Query

Park	Site	Year	Species	Common Name	Avg BB Score	AvgPctCover
SAIR	Saugus Iron Works	2004	Bare ground, peat, or sand	bare ground or peat	1	6
SAIR	Saugus Iron Works	2004	Bidens hyperborea	estuary beggarticks	0.1	0
SAIR	Saugus Iron Works	2004	Calamagrostis canadensis	Blue joint reedgrass	0.1	0.1
SAIR	Saugus Iron Works	2004	Calystegia sepium	hedge bindweed	1	5.8
SAIR	Saugus Iron Works	2004	Elatine americana	American waterwort	0	0
SAIR	Saugus Iron Works	2004	Eupatorium perfoliatum	common boneset	0.3	1.9
SAIR	Saugus Iron Works	2004	Eupatorium purpureum	sweetscented joepy	0.2	1.3
SAIR	Saugus Iron Works	2004	Impatiens capensis	jewelweed	0.8	2.9
SAIR	Saugus Iron Works	2004	Juncus effusus	common rush	0.1	0.3
SAIR	Saugus Iron Works	2004	Lythrum salicaria	purple loosestrife	0.8	3.8
SAIR	Saugus Iron Works	2004	Mikania scandens	climbing hempvine	0.3	0.4
SAIR	Saugus Iron Works	2004	Peltandra virginica	green arrow arum	1	5.4
SAIR	Saugus Iron Works	2004	Phalaris arundinacea	reed canary grass	0.4	2.6
SAIR	Saugus Iron Works	2004	Phragmites australis	common reed	2.4	27.9
SAIR	Saugus Iron Works	2004	Polygonum punctatum	dotted smartweed	0.1	0.2
SAIR	Saugus Iron Works	2004	Pontederia cordata	pickerelweed	0.2	0.3
SAIR	Saugus Iron Works	2004	Robinia pseudo-acacia	black locust	0.2	2.1
SAIR	Saugus Iron Works	2004	Rosa multiflora	multiflora rose	0.6	7.1
SAIR	Saugus Iron Works	2004	Rumex crispus	curley dock	0.1	0.1
SAIR	Saugus Iron Works	2004	Solanum americanum	American black nigh	0	0
SAIR	Saugus Iron Works	2004	Sparganium americanum	American burreed	0.2	0.5
SAIR	Saugus Iron Works	2004	Toxicodendron radicans	poison ivy	0.2	1.4
SAIR	Saugus Iron Works	2004	Typha angustifolia	narrowleaf cattail	2.4	15.8
SAIR	Saugus Iron Works	2004	Unknown species	Unknown species	0.2	0.3
SAIR	Saugus Iron Works	2004	wrack& litter	litter	0.7	2.7

Record: 1 of 45

depending on your needs.

- Click *Preview* to view the table or *Export* to save it to an Excel formatted file (Fig. 8-4).

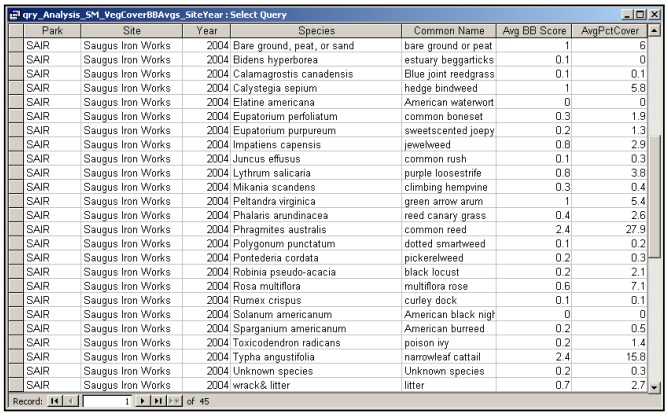


Figure 8-4. Export table of Braun-Blanquet data

Formatted: Indent: Left: 0", Tab stops: -0.13", Left + Not at 1.25"

To create a report or export the data for only a subset of the data, you will need to edit the criteria in the base query: "qry_Analysis_SM_VegCoverBB". Follow the instructions in the section "Subsetting Query Data. *Be sure to go back to the base query and remove your changes before running any other analyses!*

8.5 Subsetting Query Data

Formatted: Indent: Left: 0", Tab stops: 0", Left + Not at 1.25"

Formatted: Font: (Default) Times New Roman, 12 pt, Not Bold, Not Italic, Underline

Formatted: Heading 2

Formatted: Font: (Default) Times New Roman, 12 pt, Not Bold

Formatted: Font: (Default) Times New Roman, 12 pt, Not Bold, Not Italic, Underline

Formatted: Bullets and Numbering

~~4. Subsetting Query Data~~

The Salt Marsh Monitoring database includes a large number of analytical queries and reports for annual reporting and importing to other analytical software packages. There will be times, when researchers and park staff may want the data but for only a subset of the entire regional project. Obvious examples of this will be exporting data for only the current year, displaying data for one park, or for more specific analysis summarizing specific locations within one site. To subset the data, the user will need to edit the criteria in the appropriate query before exporting or printing the selected output.

~~4.1~~8.5.1 *Backing up the database front end interface*

~~If you haven't done so already, it is a good idea to~~ Bbackup the database front-end before editing any queries. This cannot be done from within the database. The backup options available on startup and from the main menu are only for the backend data file.

- To backup the front end, make a copy of the *MonitoringSM.mdb* file.

~~*The backup options available on startup and from the main menu are only for the backend data file.*~~

~~*To backup the front end, make a copy of the MonitoringSM.mdb file.*~~

~~4.2~~8.5.2 *Opening the Query*

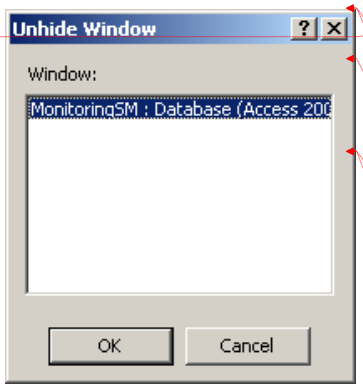
~~4.2.1~~Determine the name of the query.

- For each of the reporting options described throughout this SOP, queries are used to compile and analyze the data. To determine the name of the query you need to edit, review the relevant section of this SOP, where the name of the base query will be listed. Query names will usually start with "qry_Analysis_SM*".

~~4.2.2~~8.5.3 *Open the database window*

The database window displays the list of tables, queries, reports, etc. This window is usually hidden in the Salt Marsh Monitoring database to avoid confusion.

- To open the database window, select*Unhide* from the *Window* menu at the top of the Access application (Fig. 8-5).
- Select the MonitoringSM database.
- C~~and c~~lick *OK*.



Formatted: Font: (Default) Times New Roman, 12 pt, Not Bold, Italic
Formatted: Heading 3
Formatted: Bullets and Numbering
Formatted: Bulleted + Level: 1 + Aligned at: 0.5" + Tab after: 0.75" + Indent at: 0.75"
Formatted: Bullets and Numbering
Formatted: Font: (Default) Times New Roman, 12 pt, Not Bold, Italic
Formatted: Heading 3, No bullets or numbering
Formatted: Heading 3
Formatted: Font: (Default) Times New Roman, 12 pt, Not Bold
Formatted: Font: (Default) Times New Roman, 12 pt, Not Bold, Italic
Formatted: Font: 12 pt
Formatted: Normal, Bulleted + Level: 1 + Aligned at: 0.5" + Tab after: 0.75" + Indent at: 0.75"
Formatted: Font: 12 pt
Formatted: Bullets and Numbering
Formatted: Font: (Default) Times New Roman, 12 pt, Not Bold, Italic
Formatted: Heading 3, Indent: First line: 0", Tab stops: Not at 1.19"
Formatted: Bullets and Numbering
Formatted: Indent: Left: 0", Tab stops: 0", Left + Not at 1.25"
Formatted: Bulleted + Level: 1 + Aligned at: 0.25" + Tab after: 0.5" + Indent at: 0.5", Tab stops: 0", Left + Not at 1.25"
Formatted: Bullets and Numbering

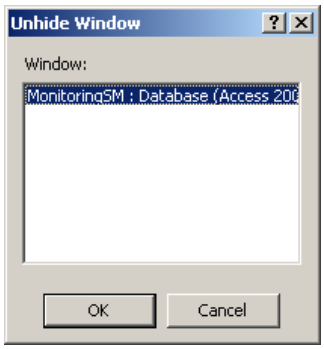


Figure 8-5~~2~~444. Unhide Window~~.~~

8.5.4 Open the Query in Design view

- From the list of objects along the left side of the database window, select *Queries*.
- –The right side of the window will display the list of all available queries.
- –Highlight the query you need to edit.
- With the query highlighted, click the design view button in the upper left of the window.

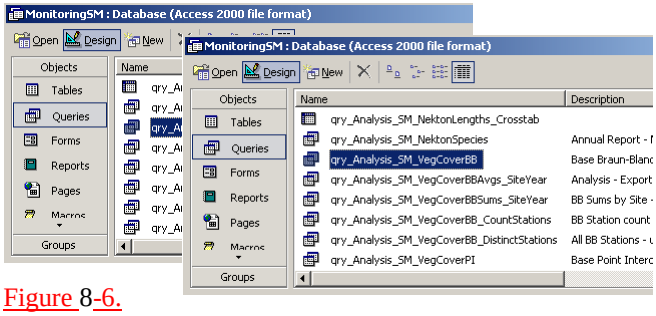
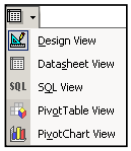


Figure 8-6. Query in design view.

~~4.3~~8.5.5 Editing the Query

The design view of a query will show you the queries and tables whose data are the input to the query, and how each of fields is defined (Fig. 8-7). If you click the view button in the far left of the toolbar, you can see the query output in datasheet view or return to the design view.



The design view has two main sections. The upper section shows the tables or queries that are input and how they relate to one another. The lower section defines the output fields and criteria. *Only edit the lower section criteria in the design view*. All further directions below refer to the lower section only.

Formatted: DM 1.1.1 Text, Indent: First line: 0", Tab stops: 0", Left + Not at 1.19"

Formatted: Bullets and Numbering

Formatted: Font: (Default) Times New Roman, 12 pt, Not Bold, Italic

Formatted: Heading 3, Indent: First line: 0", Tab stops: Not at 1.19"

Formatted: Bullets and Numbering

Formatted: Bulleted + Level: 1 + Aligned at: 0.25" + Tab after: 0.5" + Indent at: 0.5", Tab stops: 0", Left + Not at 1.25"

Formatted: Font: (Default) Times New Roman, 12 pt, Not Bold, Italic

Formatted: Heading 3

Formatted: Bullets and Numbering

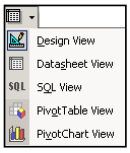


Figure 8-7. Design view.

~~4.3.1~~8.5.6 *Check for existing criteria*

This step is critically important! Before you begin editing criteria, you must check to see what criteria are already included in the query. For instance a nekton vs vegetation may include *protocol = "SMN". Any field that already has a criteria, you should not edit!* If you edit existing criteria, the dependent queries and reports will no longer be valid. Be sure you know which criteria are part of the original query, and *do not remove these when you reset the query!*

~~4.3.2~~8.5.7 *Determine the fields to subset*

Along the left of the window are the row identifiers: *Field*, *Table*, *Sort*, etc. The top row is the field row and this includes the field names and definitions. A colon is used to separate a field name from its definition. If there is no colon, the field name is whatever string is listed in that cell. From the list of fields, determine which you need to edit. In this example, the field names are: *Park, Site, Station, Year, and Method*. To include only data from 2004, you will need to edit the year field. To restrict the data to "King Creek" in "Colonial National Park", you will need to edit both the *Park* and *Site* fields.

Field:	Park: ParkCode	Site: SiteName	Station: StationID	Year	Method

Field:	Park: ParkCode	Site: SiteName	Station: StationID	Year	Method

Figure 8-~~82~~888~~.~~ Fields in database.

~~4.3.3~~8.5.8 *Determine the field values to express*

To write out specific criteria, you need to know the field values. In the above example, if you want to include only data from Colonial National Park, you need to know if the query values for Colonial National Park are "Colonial", "Colonial National Park", or "COLO". If you are unsure of the exact format of the values you need, return to the *Datasheet view* by clicking on the view button as described above. Scroll through the data until you see the values you are looking for. Then return to the *Design view*, and continue. In the Figure 8-9, you can see that the park value for Colonial is "COLO".

Formatted: Font: (Default) Times New Roman, 12 pt, Not Bold, Italic

Formatted: Heading 3, Indent: First line: 0", Tab stops: Not at 1.19"

Formatted: Bullets and Numbering

Formatted: Border: Top: (No border), Bottom: (No border), Left: (No border), Right: (No border)

Formatted: Font: (Default) Times New Roman, 12 pt, Not Bold, Italic

Formatted: Heading 3, Indent: First line: 0", Tab stops: Not at 1.19"

Formatted: Bullets and Numbering

Formatted: Indent: Left: 0", Tab stops: 0", Left + Not at 1.25"

Formatted: Font: (Default) Times New Roman, 12 pt, Not Bold, Italic

Formatted: Heading 3, Indent: First line: 0", Tab stops: Not at 1.19"

Formatted: Bullets and Numbering

qry_Analysis_SM_VegCoverPI : Select Query

Park	Site	Station	Year	Method	Scientific
COLO	King Creek	1-00	2003	50 Point Intercept	Typha angustifo
COLO	King Creek	1-100	2003	50 Point Intercept	Distichlis spicat
COLO	King Creek	1-100	2003	50 Point Intercept	Spartina alternif
COLO	King Creek	1-100	2003	50 Point Intercept	Spartina patens
COLO	King Creek	1-50	2003	50 Point Intercept	Distichlis spicat

Record: 1 of 59

Figure 8-9. Datasheet view.

~~*If you are unsure of the exact format of the values you need, return to the Datasheet view by clicking on the view button as described above. Scroll through the data until you see the values you are looking for. Then return to the Design view, and continue. In the figure below, you can see that the park value for Colonial is "COLO"*~~

qry_Analysis_SM_VegCoverPI : Select Query

Park	Site	Station	Year	Method	Scientific
COLO	King Creek	1-00	2003	50 Point Intercept	Typha angustifo
COLO	King Creek	1-100	2003	50 Point Intercept	Distichlis spicat
COLO	King Creek	1-100	2003	50 Point Intercept	Spartina alternif
COLO	King Creek	1-100	2003	50 Point Intercept	Spartina patens
COLO	King Creek	1-50	2003	50 Point Intercept	Distichlis spicat

Record: 1 of 59

~~4.3.4~~8.5.9 *Enter the criteria*

The type of criteria you are using determines how it will be expressed. In all cases, the criteria will be entered into the *Criteria* row.

~~4.3.4.1~~8.5.9.1 *Entering exact values*

An exact value will be where you know what the value of the field data are exactly. There may be more than one value, but you can express the value in exact terms. In the example above, the park value is "COLO". Year would be 2003.

Once you know the exact value you want you need to enter it into the Criteria row. Enter text values with quotations and numeric values without quotations. To enter more than one value for a given field, (*e.g.* Colonial, Boston Harbor Islands, and Fire Island) use the

Field:	Park: ParkCode	Site: SiteName	Station: StationID	Year
Table:	qry_Events_SM_Ve	qry_Events_SM_Ve	qry_Events_SM_Ve	qry_Events_SM_Ve
Sort:	Ascending	Ascending	Ascending	
Show:	☑	☑	☑	☑
Criteria:	"COLO"	"King Creek"		2003
or:				

Or and subsequent rows under *Criteria* (Fig. 8-10).

Formatted: Font: Italic

Formatted: Font: Italic

Formatted: Font: Italic

Formatted: Font: (Default) Times New Roman, 12 pt, Not Bold, Italic

Formatted: Heading 3, Indent: First line: 0", Tab stops: Not at 1.19"

Formatted: Bullets and Numbering

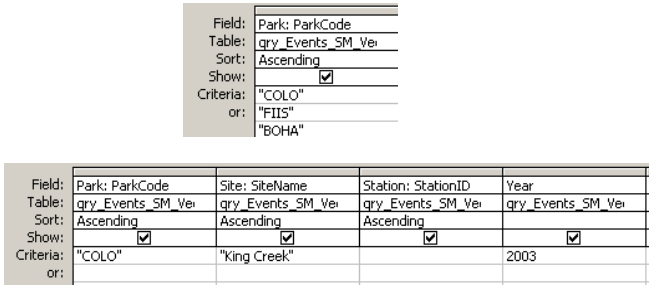
Formatted: Indent: Left: 0", Tab stops: 0", Left + Not at 1.25"

Formatted: Font: 12 pt, Not Bold, Italic, Underline

Formatted: Heading 4

Formatted: Bullets and Numbering

Formatted: Font: Italic



Field:	Park: ParkCode			
Table:	qry_Events_SM_Ve			
Sort:	Ascending			
Show:	☑			
Criteria:	"COLO"			
or:	"FIIS"			
	"BOHA"			

Field:	Park: ParkCode	Site: SiteName	Station: StationID	Year
Table:	qry_Events_SM_Ve	qry_Events_SM_Ve	qry_Events_SM_Ve	qry_Events_SM_Ve
Sort:	Ascending	Ascending	Ascending	
Show:	☑	☑	☑	☑
Criteria:	"COLO"	"King Creek"		2003
or:				

Figure 8-10. Criteria for queries

~~To enter more than one value for a given field, say Colonial, Boston Harbor Islands, and Fire Island, use the *Or* and subsequent rows under *Criteria*.~~

Field:	Park: ParkCode
Table:	qry_Events_SM_Ve
Sort:	Ascending
Show:	☑
Criteria:	"COLO"
or:	"FIIS"
	"BOHA"

~~4.3.4.2~~8.5.9.2 *Entering a range of text values*

Formatted: Font: 12 pt, Not Bold, Italic, Underline

Formatted: Heading 4

Formatted: Bullets and Numbering

An example where this is useful is in subsetting stations within a site. This works using wildcard values, when using the *Or* is unrealistic. For example, in 2004, three transects were used for measuring vegetation data with the 50 point intercept method. The first transect has 13 stations, the second has 10 stations, and the third has 9. To include only data from transect 1 would require 13 *Or* statements or one wildcard statement.

The BOHA station~~s~~ names are the year, the transect and the distance along the transect. So, a distance of 10 meters along transect 1 in 2004, is station "04_T1-10". To include all T1 stations, use a wildcard expression such as "*T1*" (Fig. 8-11). To be sure that you only include BOHA stations, enter criteria for park and site as well.

Formatted: Indent: Left: 0"

When entering wildcard expressions as criteria, it is necessary to include the word *Like* (Fig. 8-11) before the expression so Access will interpret it as an approximation with wildcards rather than an exact value.

Field:	Park: ParkCode	Site: SiteName	Station: StationID
Table:	qry_Events_SM_Ve	qry_Events_SM_Ve	qry_Events_SM_Ve
Sort:	Ascending	Ascending	Ascending
Show:	☑	☑	☑
Criteria:	"BOHA"	"Boston Harbor Islands	Like "*T1*"

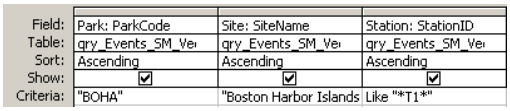
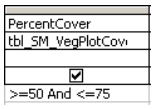


Figure 8-11. Entering a range of values

~~4.3.4.3~~8.5.9.3 *Entering numeric ranges*

Set up numeric range criteria just as you would in standard math notation.

- T~~For instance, t~~o select all percent cover measurements between 50 and 75% enter >=50 And <=75 (Fig. 8-12).~~.~~
- Remember quotations are for text values only.



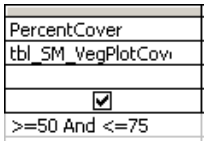


Figure 8-12. Entering numeric ranges.

Formatted: Font: 12 pt, Not Bold, Italic, Underline

Formatted: Heading 4

Formatted: Bullets and Numbering

Formatted: Indent: Left: 0"

Formatted: Bulleted + Level: 1 + Aligned at: 0.5" + Tab after: 0.75" + Indent at: 0.75"

Formatted: Bullets and Numbering

Formatted: Indent: Left: 0"

~~4.3.4.4~~8.5.9.4 *Entering dates*

Set up your date criteria just as you would the other criteria, but you will need to bracket dates with #'s just as you would use quotes to bracket text. For example to include only data from June 2004, your criteria would be >=#6/1/2004# And <=#6/30/2004# (Fig. 8-13).~~.~~

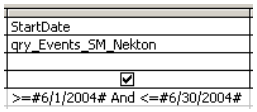


Figure 8-13. Entering dates

~~4.3.5~~8.5.10 *Check your criteria*

- To see if you have entered your criteria correctly, switch to *Datasheet view* and scroll through your data.
- If you have an empty query, you have entered an invalid ~~criteri~~criterion~~a~~ for which no data have that value. This can ~~easily~~ be caused by a misspelling o~~.~~ ~~O~~r ~~perhaps the answer is~~ there are no data meeting your criteria.
- If you do not see the data you expect, recheck your criteria.
- You may need to remove all your criteria and review the original query to determine if you are having difficulty with the data or with your criteria.

~~4.3.6~~8.5.11 *Save and close*

- Once you have entered your criteria, you must save the query.
- Click the save button in the upper left corner of the Access application window.
- ~~-~~Close the query

~~4.4~~8.6 *View the output*

~~-~~Return to the output menus.

-
- Bring the *Main Menu* forward again, and select *Analysis and Export*.
- Select either *Summary Reports* or *Export Data to Excel*, depending on which data you ~~are interested~~want to view~~ in~~.~~.~~

~~4.4.2~~8.6.1 *Preview the new data*

- Select the export or report data and click *Preview*.
- If the data output is as you export, you are ready to print or export.
- If the data are not as you expect, review your criteria-setting steps above.
- If the data are still not what you expect, contact your Data Administrator for further assistance.

Formatted: Font: 12 pt, Not Bold, Italic, Underline
Formatted: Heading 4
Formatted: Bullets and Numbering
Formatted: Indent: Left: 0"
Formatted: Font: (Default) Times New Roman, 12 pt, Not Bold, Italic, Underline
Formatted: Heading 3, Indent: First line: 0", Tab stops: Not at 1.19"
Formatted: Bullets and Numbering
Formatted: Bulleted + Level: 1 + Aligned at: 0.25" + Tab after: 0.5" + Indent at: 0.5", Tab stops: 0", Left + Not at 1.25"
Formatted: Font: (Default) Times New Roman, 12 pt, Not Bold, Italic, Underline
Formatted: Heading 3, Indent: First line: 0", Tab stops: Not at 1.19"
Formatted: Bulleted + Level: 1 + Aligned at: 0.25" + Tab after: 0.5" + Indent at: 0.5", Tab stops: 0", Left + Not at 1.25"
Formatted: Bulleted + Level: 1 + Aligned at: 0.25" + Tab after: 0.5" + Indent at: 0.5", Tab stops: 0", Left + Not at 1.25"
Formatted: Font: (Default) Times New Roman, 12 pt, Not Bold
Formatted: Heading 2
Formatted: Font: 12 pt
Formatted: Normal, Bulleted + Level: 1 + Aligned at: 0.25" + Tab after: 0.5" + Indent at: 0.5"
Formatted: Bullets and Numbering
Formatted: Font: 12 pt
Formatted: Bullets and Numbering
Formatted: Bullets and Numbering
Formatted: Font: 12 pt
Formatted: Bullets and Numbering
Formatted: Font: 12 pt
Formatted: Font: 12 pt
Formatted: Font: (Default) Times New Roman, 12 pt, Not Bold, Italic, Underline
Formatted: Heading 3, Indent: First line: 0", Tab stops: Not at 1.19"
Formatted: Bulleted + Level: 1 + Aligned at: 0.25" + Tab after: 0.5" + Indent at: 0.5", Tab stops: 0", Left + Not at 1.25"

~~4.5~~*8.7 Remove the query criteria*

When you have finished and printed or exported the subsetted data you need, *be sure to return the query to its original form!* If you do not remove your subsetting criteria, other users, or yourself will have unexpected results when using the data export and reporting tools. ~~This may be weeks or even a year later, long after these steps have been forgotten.~~ It is particularly important to remove subsetting criteria immediately ~~do it sooner, rather than later,~~ because some of the criteria in the query may be part of the original, and should not be removed. ~~If you do not clean up your work immediately, other users, or even yourself, will have no way to know which criteria should be kept and which removed.~~

- Using the directions above as needed.
- ~~,~~O~~o~~pen the query in design view again.
- Delete each of the criteria you have entered.
- Save and close the query.

8.8 Quality Control in Annual Data Reports

Formatted: Font: (Default) Times New Roman, 12 pt, Not Bold

Formatted: Heading 2

Formatted: Bullets and Numbering

Formatted: Font: (Default) Times New Roman, 12 pt, Not Bold

Formatted: Heading 2

Formatted: Bullets and Numbering

~~5.~~*~~Quality Control in Annual Data Reports~~*

The series of automated annual reporting summaries, have undergone a quality control review during development. When using these annual reporting tools, it is imperative that researchers continue to review these data summaries each time they are used.

~~5.1~~*8.8.1 Development Quality Control*

The Network has performed quality control on the summary reports prior to their release. This quality control consists of cross-checking the following items:

1. ~~1.~~Field names and values – are the necessary fields included in the summaries, and do these fields display the appropriate information?

   Each field name and the values reported ~~is~~ are checked for all queries and reports.

2. ~~2.~~Record counts – do the summary queries and reports have the correct number of records?

   The number of records in each output query is compared to the number of records in the input tables and queries. Insufficient record counts may still arise if not all of the field data has been entered into the database.

3. ~~3.~~Sample counts –does each average or other summary calculation have the correct sample number?

   Summary statistics combine data from a series of events, usually by site and year. The number of events combined for that statistic for that site and year is the sample number. Sample numbers are spot-checked.

4. ~~4.~~Sample sums – do the reported totals equal the sum of the data values?

   Totals are spot-checked for various subsets of the data, based on the summary.

5. ~~5.~~ Summary values- are the summary statistics accurate?

   Summary statistic values are also spot-checked. If independent calculations are available, the summary values are compared with the independent values. Where independent summary values are not available, spot checks are made. Particularly with averages, since most queries will include both the total and the sample count, both of which have been checked.

~~5.2~~*8.8.2 Reporting Quality Control*

Each time the summary data are exported for inclusion in an annual report, the individual responsible for reporting must perform a basic quality control check before disseminating the report data. Even though the analysis development has been checked, it is important for the specific data report values to be checked as well. This will help detect errors in data entry and any changes made to the summaries through subsetting of the base queries.

Formatted: Font: (Default) Times New Roman, 12 pt, Not Bold, Italic, Underline
Formatted: Heading 3
Formatted: Bullets and Numbering
Formatted: Indent: Left: 0"
Formatted: Bullets and Numbering
Formatted: Bullets and Numbering
Formatted: Bullets and Numbering
Formatted: Bullets and Numbering
Formatted: Bullets and Numbering
Formatted: Bullets and Numbering
Formatted: Bullets and Numbering
Formatted: Bullets and Numbering
Formatted: Font: (Default) Times New Roman, 12 pt, Not Bold, Italic, Underline
Formatted: Heading 3

~~1.~~Data entry quality control – before running summary analyses and checking them for accuracy, it is necessary to perform quality control on the data entry. If the data have been entered with inaccurate data, or if data entries are missing, the summary analyses will be incorrect.

~~2.~~Data aggregation units – are all the parks, sites, locations and dates that you are reporting on included in the summary? If not, be sure to check the base query to be sure that no subsetting remains from a previous report.

~~3.~~Record counts – depending on the type of summary or export, you cross-check against the number of field events. ~~Otherwise~~For example, do you have data reported for each park and site? If data are not summarized by site, do you have data for each sampling location? If locations were visited more than once during the year, do you have matching data from each sampling trip?

~~4.~~Sample counts – if you are summarizing by site, do you have the correct number of locations included in your sample count? If you are reporting averages, do you have the correct number of sample counts for each event. If you have more than one data value for an event, (*e.g.*, nekton sampling lengths), do you have the correct number of samples per location (*e.g.*, compare sample size (n) for nekton lengths, with the sample size (n) for nekton collection).

~~5.~~Sample sums – spot check the totals by performing the calculation independently for a few of the data values.

~~6.~~• Summary values – spot check the values by performing the calculation independently for a few of the data values. T~~With averages t~~his can be particularly easy if both the total and the sample counts are also reported.

Formatted: Bullets and Numbering
Formatted: Bullets and Numbering
Formatted: Bullets and Numbering
Formatted: Bullets and Numbering
Formatted: Bullets and Numbering
Formatted: Bullets and Numbering
Formatted: Font: Italic
Formatted: Font: Italic
Formatted: Bullets and Numbering
Formatted: Bullets and Numbering
Formatted: Bullets and Numbering
Formatted: Bullets and Numbering
Formatted: Heading 1

~~6.References~~

~~Rice. 1989~~
~~Zar. 1999~~
~~Carr 1997. Plymouth Routines In Multivariate Research~~
~~Clarke and Warwick 1994~~

Formatted: DM 1 Text

9 SOP 9: Data Analyses

9.1 Vegetation Data

9.2 Annual Reporting

- Species lists should be made for each sampling site (*i.e*., marsh).
- Calculate the average percent cover for each species or other cover class per marsh (plots are the replicates).
    - Add up the total number of hits per cover type for each plot. There is a box on the raw data sheet for this total.
    - Calculate the average percent cover per species per plot [*e.g*., if species A had 10 hits this is equivalent to a 20% cover (10 hits/50 total points for the plot)].

9.2.1 Trend Reports

- A community analysis to determine trend in vegetation communities over time is conducted for the trend reports once there is enough data (*e.g*. two or more years of data).
- A community analyses that we often use are part of the PRIMER software package (http://www.primer-e.com), that use non-parametric tests to detect differences in community structure (*i.e*., species composition and abundance). Non-parametric permutation testing procedures can be effectively used to evaluate dissimilarity or similarity in nekton communities between marshes or between sample years. ANOSIM, part of the PRIMER statistical package (Plymouth Routines In Multivariate Research, Carr 1997) is just one example of a non-parametric test, similar to multivariate analysis of variance (MANOVA) but without the generally unattainable assumptions (Clarke and Warwick 1994; Carr 1997). The ANOSIM procedure calculates a similarity measure (such as the Euclidean Distance measure), and a similarity matrix is created that allows for the objective identification of samples (*e.g.*, vegetation plots) that have similar (or dissimilar) communities in terms of species composition and abundance. All pair-wise comparisons are summarized into a test statistic using Clark's R that compares between-group to within-group dissimilarities. Monte Carlo permutation tests are then used to derive p-values.
- When using the ANOSIM software program for vegetation community composition analyses we use the defaults of the program (no standardization, no transformation), and the Euclidean distance metric.
    - Pairwise comparisons between groups of samples are defined *a priori* to detect differences in communities (*e.g.*, 2001 vs. 2002).
    - A Bonferroni correction (Zar 1999) or step-wise Bonferroni correction (Rice 1989) for the experiment-wise error is made based on the number of comparisons being tested. For example, the Bonferroni correction for 4 pair-wise comparisons at a probability level is 0.05, would result in an adjusted alpha level of 0.05/4 or 0.0125. Any

comparisons having p-values below 0.0125 would be significantly different.

- For pairwise comparisons that are significant, or have dissimilar communities, it is often desirable to know what contribution the individual species or cover types made to the dissimilarity. The proportion of the overall dissimilarity that is contributed by individual cover types or species can be calculated as follows;

Where;

$$1 - \frac{}{D_{max}} = 1 - \frac{(C_{1i} - C_{2i})^2}{\sum (C_{1i} - C_{2i})^2}$$

D = Distance

C_{1i} = abundance of cover type or species i in marsh at time 1 (or in Marsh 1 when comparing marshes)

C_{2i} = abundance of cover type or species i in marsh at time 2 (or in Marsh 2 when comparing marshes)

- The outcome is a list of species and cover types ranked in order of their percent contribution to the dissimilarity between significant pairwise comparisons. D_{max} (based on Euclidean Distance) provides an overall measure of dissimilarity for each pairwise comparison. D_{max} values can be used to determine if communities on different marshes are becoming more similar. For example, as D_{max} values become more alike (i.e., closer together), this is indicates that the communities of the marshes are becoming more similar. Conversely, as D_{max} become farther apart, this indicates that communities are becoming more dissimilar.

9.3 Groundwater Table Level and Soil Salinity Data

9.3.1 Annual Reports

- Calculate an average for groundwater table and soil salinity for each marsh (station locations are the replicates).
- An estimate of error (standard error or standard deviation) and sample size (number of stations sampled) should be presented.

9.3.2 Trend Reports

- An Analysis of Variance (ANOVA) can be used to determine if groundwater table or soil salinity of marshes are changing over time or are different among marshes. The dependent variable would be groundwater table or soil salinity and the independent variable would be either year or site, depending on the hypothesis. If more than two years or sites are compared then a post hoc test (*e.g.*, Least Square Means, Tukey) should be used to determine where significant differences are found.

- All data should be checked to ensure that the assumptions of the ANOVA are met (*e.g.*, normality, homogeneity of variances).
- If data do not meet the assumptions of ANOVA then transformations can be conducted or a non-parametric equivalent (*e.g.*, Kruskal-Wallis) can be employed.

10 SOP 10 - Reporting and Review (placeholder for Network)

11 SOP 11: Completion of Field Season: Procedures for Equipment Storage

11.1 Maintenance and Repairs

- All sampling equipment should be cleaned and repaired (if required) prior to storage. Proper storage will help maintain the life of equipment for future sampling endeavors.
- Re-order equipment if necessary (*i.e.*, meter sticks)
- Batteries should be removed from all electronic equipment when not in use for extended periods of time.

12 SOP 12 - Revising the Protocol or SOP (Placeholder for Network)

This protocol is a revision of a protocol first developed by Roman *et al*. (2001) for use in the Long-term Coastal Monitoring Program at Cape Cod National Seashore. The original protocol can be found that the National Park Service Inventory and Monitoring website: http://www.nature.nps.gov/im/monitor/protocoldb.cfm

This protocol was revised for the following reasons:
To conform to NPS format guidelines

This protocol was revised December 2004 by:
Mary-Jane James-Pirri
Box 8
Graduate School of Oceanography, University of Rhode Island
Narragansett, RI 02882
Phone:(401) 874-6617 Fax: (401) 874-6887
e-mail: mjjp@gso.uri.edu

Previous Version	Revision Date	Author	Changes Made	Reason for Change	New Version #
Original Protocol	12/9/04	Mary-Jane James-Pirri mjjp@gso.uri.edu	Format Changes	Conform to NPS guidelines	#1

Literature Cited

Able, K.W., K.L. Heck, Jr., M.P. Fahay, and C.T. Roman. 1988. Use of salt-marsh peat reefs by small juvenile lobsters on Cape Cod, Massachusetts. *Estuaries* 11: 83-86.

Ayvazian S.G., L.A. Deegan, and J.T. Finn. 1992. Comparison of habitat use by estuarine fish assemblages in the Acadian and Virginian zoogeographic provinces. *Estuaries* 15: 368-383.

Bertness, M.D. 1999. *The Ecology of Atlantic Shorelines*. Sinauer Associates Inc., Sunderland, MA. 417 pp.

Bourn, W.S. and C. Cottam. 1950. Some biological effects of ditching tidewater marshes. Research Report 19. US Fish and Wildlife Service, Washington, DC.

Brush, T., R.A. Lent, T. Hruby, B.A. Harrington, R.M. Marshall, and W.G. Montgomery. 1986. Habitat use by salt marsh birds and response to Open Marsh Water Management. *Colonial Waterbirds* 9: 189-195.

Burdick, D.M., M. Dionne, R.M. Boumans, and F.T. Short. 1997. Ecological responses to tidal restorations of two northern New England salt marshes. *Wetlands Ecology and Management* 4: 129-144.

Burger, J., J.K. Shisler, and F.H. Lesser. 1982. Avian utilization on six salt marshes in New Jersey. *Biological Conservation* 23: 187-212.

Carr, M. R. 1997. PRIMER (Plymouth Routines in Multivariate ecological Research) User Manual. Plymouth: Plymouth Marine Laboratory, 27+ p.

Clarke, K.R. and Green, R.H. 1988. Statistical design and analysis for a 'biological effects' study. *Mar. Ecol. Prog. Ser.* 92:205-219.

Clarke, K. R. and Warwick, R. M. 1994. Change in marine communities: an approach to statistical analysis and interpretation. Plymouth: Plymouth Marine Laboratory, 114 p.

Dahl, T.E. 1990. Wetlands losses in the United States, 1780's to 1980's. United States Department of the Interior, Fish and Wildlife Service, Washington, DC. 21 pp.

Daiber, F.C. 1986. *Conservation of Tidal Marshes*. Van Nostrand Reinhold Co., New York.

Dean, R.G. 1979. Effects of vegetation on shoreline erosional processes, p. 415-426. *In* P.E. Greeson, J.R. Clark and J.E. Clark (eds.), Wetland Functions and Values: The State of our Understanding. American Water Resources Association, Minneapolis, MN.

Donnelly, J.P. and M.D. Bertness. 2001. Rapid shoreward encroachment of salt marsh cordgrass in response to accelerated sea-level rise. Proceedings of the National Academy of Science 98:14218-14223.

Elzinga, C. L., Salzer, D. W., and Willoughby, J. W. 1998. Measuring and Monitoring Plant Populations. USDI, BLM National Applied Resources Center, Denver, CO; July 1998. BLM/RS/ST-98/005+1730. 492 p.

Floyd, D. A. and Anderson, J. E. 1987. A comparison of three methods for estimating plant cover. *Journal of Ecology* 75:221-228.

Greig-Smith, P. 1983. *Quantitative Plant Ecology*. University of California Press, Berkeley. 359p.

Heck, K.L., Jr., K.W. Able, M.P. Fahay, and C.T. Roman. 1989. Fishes and decapod crustaceans of Cape Cod eelgrass meadows: species composition, seasonal abundance patterns and comparison with unvegetated substrates. *Estuaries* 12: 59-65.

Howes, B.L., P.K. Weiskel, D.D. Goehringer and J.M. Teal. 1996. Interception of freshwater and nitrogen transport from uplands to coastal waters: the role of saltmarshes, p. 287-310. *In,* K.F. Nordstrom & C.T. Roman (eds.), Estuarine Shores: Evolution, Environments and Human Alterations. John Wiley & Sons, NY.

Intergovernmental Panel on Climate Change. 1995. Climate Change. *In* J.T. Houghton, L.G. Meira Filho, B.A. Callendfar, N. Harris, A. Kattenberg, and K. Maskell (eds.), The Science of Climate Change. Cambridge University Press, NY 572 pp.

James-Pirri, M.J., R.M. Erwin, and D.J. Prosser. 2004. US Fish and Wildlife Service (Region 5) Salt Marsh Study Year 3 Study Report. Technical report submitted to Janith Taylor, US Fish and Wildlife Service, Newington NH.

Kennedy, K.A., and P.A. Addison. 1987. Some considerations for the use of visual estimates of plant cover in biomonitoring. *Journal of Ecology* 75: 151-157.

Kent, M. and P. Coker. 1992. *Vegetation Description and Analysis*: A Practical Approach. John Wiley & Sons.

Kracauer-Hartig, E., V. Gornitz, A. Kolker, F. Mushacke, and D. Fallon. 2002. Anthropogenic and climate-change impacts on salt marshes of Jamaica ay, New York City. Wetlands 22:71-89.

Krebs, C.J. 1989. *Ecological Methodology*. Harper Collins. 654 p.

Miller, W.R., and F.E. Egler. 1950. Vegetation of the Wequetequock-Pawcatuck tidal- marshes, Connecticut. *Ecological Monographs* 20: 143-172.

Neckles, H.A., M. Dionne (Eds.). 2000. Regional standards to identify and evaluate tidal wetland restoration in the Gulf of Maine. Wells National Estuarine Research Reserve Technical Report, Wells, ME. 21 pp. + appendices

Neckles, H.A., M. Dionne, D.M. Burdick, C.T. Roman, R. Buchsbaum, and E. Hutchins. 2002. A monitoring protocol to assess tidal restoration of salt marshes on local and regional scales. *Restoration Ecology* 10:556-563.

Niering, W. A. and Warren, R. S. 1980. Vegetation patterns and process in New England salt marshes. *Bioscience* 30:301-307.

Nixon, S.W. 1982. The ecology of New England high salt marshes: a community profile. Technical report FWS/OBS-81/85. US Fish and Wildlife Service, Office of Biological Services, Washington, DC. 70p.

Nixon, S.W. and C.A. Oviatt. 1973. Analysis of local variation in the standing crop of *Spartina alterniflora*. *Botanica Marina* 16: 103-109.

Poissonet, P. S., Daget, P. M., Poissonet, J. A., and Long., G. A. 1972. Rapid point survey by bayonet blade. *Journal of Range Management* 25:313.

Poissonet, P.S., J.A. Poissonet, M.P. Godron, and G.A. Long. 1973. A comparison of sampling methods in dense herbaceous pasture. *Journal of Range Management* 26: 65-67.

Rice, W.R, 1989. Analyzing tables of statistical tests. *Evolution* 43: 223-225.

Roman, C.T. 2001. Salt marsh vegetation, p. 2487-2490. *In* J.H. Steele, K.K. Turekian, and S.A. Thorpe (eds.), Encyclopedia of Ocean Sciences. Academic Press, London.

Roman, C.T., R.A. Garvine, and J.W. Portnoy. 1995. Hydrologic modeling as a predictive basis for ecological restoration of salt marshes. *Environmental Management* 19: 559-566.

Roman, C.T., M.J. James-Pirri, and J. F. Heltshe. 2001. Monitoring Salt Marsh Vegetation: A Protocol for the Long-term Coastal Ecosystem Monitoring Program at Cape Cod National Seashore. Coordinated by the USGS Patuxent Wildlife Research Center, Coastal Research Field Station at the University of Rhode Island, Narragansett, RI 02882.

Roman, C.T., N. Jaworski, F.T. Short, S. Findlay, and R.S. Warren. 2000. Estuaries of the northeastern United States: habitat and land use signatures. *Estuaries* 23: 743-764.

Roman, C.T., W.A. Niering, R.S., Warren. 1984. Salt marsh vegetation change in response to tidal restriction. *Environmental Management* 8: 141-150.

Roman, C.T., J. A. Peck, J.R. Allen, J.W. King, P.G. Appleby. 1997. Accretion of a New England (U.S.A.) salt marsh in response to inlet migration, storms, and sea-level rise. *Estuarine, Coastal and Shelf Science* 45: 717-727.

Roman, C.T., K.B. Raposa, S.C. Adamowicz, M.J. James-Pirri, & J.G. Catena. 2002. Quantifying vegetation and nekton response to tidal restoration of a New England salt marsh. Restor. Ecol. 110: 450-460.

Smartt, P.F.M., S.E. Meacock, and J.M. Lambert. 1974. Investigations into the properties of quantitative vegetational data. I. Pilot study. *Journal of Ecology* 62: 735-759.

Smartt, P.F.M., S.E. Meacock, and J.M. Lambert. 1976. Investigations into the properties of quantitative vegetational data. II. Further data type comparisons. *Journal of Ecology* 64: 41-78.

Smith, E.P., Pontasch, K.W. and Cairnes, J., Jr. 1990. Community similarity and the analysis of multispecies data: a unified statistical approach. *Water Research* 24:507-514.

Sutherland, W.J., editor. 1996. *Ecological Census Techniques: a handbook*. Cambridge University Press, Cambridge, UK. 336p.

Tiner, R.W., Jr. 1984. Wetlands of the United States: current status and recent trends. US Fish and Wildlife Service, National Wetlands Inventory, Washington, DC. 59 pp.

Titus, J.G. 1991. Greenhouse effect and coastal wetland policy: How Americans could abandon an area the size of Massachusetts at minimum cost. *Environmental Management* 15: 39-58.

Warren, R.S., and W.A. Niering. 1993. Vegetation change on a northeast tidal marsh: interaction of sea-level rise and marsh accretion. *Ecology* 74: 96-103.

Zar, J. H. 1999. *Biostatistical Analysis.* 4th Ed. Prentice Hall, New Jersey. 663 plus appendices.

Appendix

This appendix present the UTM (Nad 83, meters) of sampling (nekton and vegetation) sites for each park monitored to date.

Table 0-1. Coordinates for vegetation sampling locations sampled in 2004 at BOHA, UTM, Zone 18, NAD 83, meters. * *Indicates that original GPS coordinates were not in correct location and new coordinates were estimated from GIS.*

Site	Station	UTM X (east)	UTM Y (north)
Thompson Island	1-00	333869	4686512
	1-10	333863	4686496
	1-20	333864	4686482
	1-30	In creek no data recorded	
	1-40	333868	4686463
	1-50	333869	4686452
	1-60*	333870	4686442
	1-70*	333871	4686422
	1-80	333870	4686397
	1-90	In creek no data recorded	
	1-100	In creek no data recorded	
	1-110	In creek no data recorded	
	1-120	333875	4686350
	1-130*	333876	4686338
	2-00	333915	4686510
	2-10	333915	4686488
	2-20	333921	4686483
	2-30	In creek no data recorded	
	2-40	333924	4686465
	2-50	333929	4686451
	2-60*	333930	4686441
	2-70	333932	4686431
	2-80*	333933	4686424
	2-90	333936	4686418
	2-100	333957	4686294
	3-00	334000	4686541
	3-10	In creek no data recorded	
	3-20	In creek no data recorded	
	3-30	334006	4686509
	3-40	334008	4686498
	3-50	334008	4686488
	3-60	In creek no data recorded	
	3-70	334019	4686464
	3-80*	334022	4686453
	3-90	334080	4686313
	3-100	In creek no data recorded	
	3-110	334083	4686286

Site	Station	UTM X (east)	UTM Y (north)
Thompson Island (continued)	3-120*	334085	4686272
Calf Island	1-00*	343785	4689492
	1-10	343788	4689481
	1-20	343793	4689477
	1-40	343796	4689456
	1-50	343800	4689448
	1-60*	343805	4689438
	1-70	343812	4689430
	1-80	343820	4689424
	1-90	343816	4689416
	1-100	343826	4689413
	1-110	343822	4689408
	2-00	343805	4689491
	2-10	343807	4689482
	2-40	343826	4689444
	2-50	343833	4689425
	2-60	343833	4689432
	2-70	343838	4689422
	2-80*	343843	4689414

Table 0-2. Coordinates for vegetation sampling locations sampled in 2003 at COLO, UTM, Zone 18, NAD 83, meters.

Marsh	Station	UTM X (east)	UTM Y (north)
Back River	1-00	342938	4120495
	1-30	342938	4120471
	1-60	342950	4120433
	1-90	342940	4120409
	2-00	342910	4120530
	2-30	342902	4120500
	2-60	342901	4120471
	2-90	342898	4120452
	2-120	342896	4120432
	3-00	342799	4120727
	3-50	342792	4120680
	3-100	342784	4120631
	3-150	342775	4120582
	3-200	342769	4120536
	4-00	342736	4120752
	4-50	342731	4120713
	4-100	342724	4120660
	4-150	342717	4120611
	4-200	342711	4120560
King Creek	1-00	357746	4126364
	1-50	357715	4126402
	1-100	357684	4126446
	2-00	357799	4126349
	2-50	357767	4126386
	2-100	357736	4126427
	2-150	357704	4126462
	3-00	357926	4126339
	3-50	357898	4126368
	3-100	357865	4126411
	3-150	357832	4126453
	3-200	357804	4126489
	3-250	357771	4126526
	4-00	357907	4126439
	4-50	357878	4126482
	4-100	357849	4126520
	4-150	357819	4126564

Table 0-3. Coordinates for vegetation sampling locations sampled in 2003 at FIIS, UTM, Zone 18, NAD 83, meters.

Marsh	Station	UTM X (east)	UTM Y (north)
Hospital Point	1-00	677997	4510628
	1-50	677967	4510671
	1-100	677944	4510717
	1-150	677912	4510758
	1-200	677886	4510801
	1-250	677856	4510839
	2-00	678020	4510692
	2-50	677997	4510738
	2-100	677972	4510782
	2-150	677954	4510827
	2-200	677933	4510866
	2-250	677911	4510906
	2-300	677882	4510964
	2-350	677862	4511021
	3-00	678145	4510705
	3-50	678125	4510750
	3-100	678100	4510801
	3-150	678081	4510847
	3-200	678058	4510887
	3-250	678039	4510942*
	3-300	678013	4510983
	3-350	677992	4511024
	3-400	677966	4511070
	4-00	678199	4510740
	4-50	678176	4510787
	4-100	678153	4510830
	4-150	678123	4510877
	4-200	678102	4510915
	4-250	678083	4510968
	4-300	678067	4511001
Watch Hill	1-00	670380	4506756
	1-30	670369	4506793
	1-60	670360	4506824
	1-90	670348	4506844
	2-00	670414	4506762

Marsh	Station	UTM X (east)	UTM Y (north)
Watch Hill (continued)	2-30	670414	4506791
	2-60	670417	4506820
	2-90	670418	4506849
	2-120	670419	4506878
	3-00	670459	4506776
	3-30	670459	4506811
	3-60	670452	4506839
	3-90	670453	4506859
	3-120	670451	4506894
	4-00	670510	4506779
	4-30	670511	4506811
	4-60	670508	4506841
	4-90	670501	4506870
	4-120	670508	4506898
	4-150	670511	4506928

Table 0-4. . Coordinates for vegetation sampling locations sampled in 2003 at Horseshoe Cove Marsh, GATE in 2003, UTM, Zone 18, NAD 83, meters. * *Indicates UTM coordinates of vegetation stations were estimated from GIS maps.*

Station	UTM X (east)	UTM Y (north)
1-00	584884	4478098
1-50	584827	4478089
1-100	584780	4478076
1-150*	584735	4478063
1-200	584685	4478045
1-250	584630	4478036
2-00	584838	4478131
2-50*	584791	4478122
2-100	584738	4478109
2-150	584690	4478096
2-200	584641	4478087
3-00	584814	4478181
3-50	584758	4478176
3-100	584710	4478175
3-150*	584663	4478165
3-200	584613	4478156
4-00	584783	4478216
4-50	584735	4478206
4-100	584687	4478197
4-150	584639	4478186
4-200	584591	4478174

Table 0-5. Coordinates for vegetation sampling locations at SAIR in 2004, UTM, Zone 19, NAD 83, meters. A indicates plots on eastern side of river, B indicates plots on western side of river. * *Indicates UTM coordinates of stations were estimated from GIS maps because original GPS* ***coordinates did not match up with adjacent stations.***

Station	UTM X (east)	UTM Y (north)
1A-00	335013	4703817
1B-00	334986	4703818
1B-10*	334976	4703818
2B-00	334990	4703790
2B-10*	334983	4703790
2B-20	334977	4703789
2B-30	334968	4703789
2B-40	334959	4703789
3B-00	334977	4703781
3B-10	334968	4703781
3B-20	334961	4703781
3B-30*	334952	4703781
4B-00	334964	4703761
4B-10	334957	4703761
4B-20*	334949	4703761
4B-30	334941	4703761
5A-00	334955	4703672
5B-00*	334939	4703671
5A-10*	334962	4703672
5A-20	334970	4703673
5A-30	334978	4703670
5A-40	334990	4703671
6A-00	334953	4703613
6A-10	334964	4703615
6A-20	334977	4703619
6A-30	334984	4703617
6A-40	334991	4703621
7A-00	335009	4703554
7A-10*	335017	4703559
7A-20	335025	4703565

Table 0-6. Coordinates for vegetation sampling locations at SAHI in 2004, UTM, Zone 18, NAD 83, meters. * *Indicates UTM coordinates of stations were estimated from GIS maps because original GPS coordinates did not match up with adjacent stations.*

Station	UTM X (east)	UTM Y (north)
1-00	627212	4527117
1-20	627196	4527116
1-40	627181	4527114
1-60	627164	4527104
2-00	627209	4527152
2-20	627180	4527148
2-40	627176	4527141
2-60*	627156	4527135
3-00	627195	4527168
3-20	627180	4527172
3-40	627158	4527161
4-00*	627194	4527217
4-20*	627183	4527215
4-40*	627171	4527212
4-60*	627160	4527210
4-80*	627147	4527207
5-00	627096	4527065
6-00	627086	4527092
6-20	627111	4527086
6-40	627130	4527102
6-60	627149	4527104
7-00	627092	4527113
7-20	627116	4527124
7-40	627138	4527130
7-60	627148	4527144
8-00	627098	4527149
8-20	627111	4527150
8-40	627126	4527151
9-00	627084	4527183
9-20*	627123	4527202
9-40*	627136	4527203